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RELATIONSHIPS OF TASTE PERCEPTION AND DIETARY INTAKE: COMPARISON OF ELDERLY AND YOUNG WOMEN

BY

©

SUSANNA YUK YING KO

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

IN

FOODS AND NUTRITION

FACULTY OF HOME ECONOMICS

EDMONTON, ALBERTA

SPRING 1987

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ISBN 0-315-37771-2

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DEGREE: Master of Science

YEAR THIS DEGREE GRANTED: 1987

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled " Relationships of taste perception and dietary intake: Comparison of elderly and young women" submitted by Susanna Yuk Ying Ko in partial fulfilment of the requirements for the degree of Master of Science in Foods and Nutrition.

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ABSTRACT

Suprathreshold taste perception and dietary intake of sixty free-living females (30 elderly and 30 young) were assessed and relationships between taste perception and nutrient intake were examined.

Taste perception was evaluated by magnitude estimation for both taste intensity and taste pleasantness. Two taste qualities (sourness and saltiness) and two systems (aqueous and food) were studied. Dietary intakes were assessed quantitatively for four days by means of a combination of dietary recall (one day) and food records (three days).

The slopes for the regression of taste intensity on concentration revealed that the slopes for the elderly were consistently flatter than those for the young. The slopes for the elderly and young, respectively, were as follows: for sourness: aqueous (0.47, 0.77, $p<0.001$), food (0.33, 0.60, $p<0.001$) and for saltiness: aqueous (0.50, 0.71, $p<0.001$), food (0.42, 0.50, N.S.). Taste intensity slopes for food systems were consistently flatter than those for aqueous systems.

Within each age group the slopes of taste intensity functions were ranked. For each age group, two subgroups were created (n=15): subgroup I with steeper slopes and subgroup II with flatter slopes. For each subject an index of nutritional risk was computed as the average of the percent risk of nutrient deficiency values for twelve nutrients (protein, thiamin, riboflavin, folacin, vitamin

B_6, vitamin B_{12}, vitamin A, vitamin D, ascorbic acid, calcium, iron, and zinc). For the elderly, the mean index of nutritional risk was significantly higher for subgroup I than for subgroup II for both taste qualities in each food system (sourness $p<0.05$, saltiness $p<0.01$). For subgroup I, the mean indices of hedonic response (calculated as the absolute difference between the highest and lowest log pleasantness ratings) were significantly greater than for subgroup II for both age groups for both taste qualities in each system.

The dietary data indicated that the elderly had poorer diets than the young. For the elderly, the probability estimates of nutrient deficiency were: folacin 39%, calcium 31%, zinc 23%, vitamin A 12% and vitamin D 11%. For the young, the probability estimates of nutrient deficiency were: folacin 16%, vitamin A 11% and zinc 11%. For the elderly, significant positive correlations were noted between percent risk of vitamin A deficiency and all the slopes of taste intensity functions.

One of the most important findings in the present study was that, for the elderly, the subgroup with steeper slopes of taste intensity was at greater nutritional risks than the subgroup with flatter slopes.

ACKNOWLEDGEMENTS

The author wishes to thank her supervisors, Professor Margaret Gee and Dr. Zenia Hawrysh, for their guidance throughout the entire study. The author would also like to extend her sincere appreciation to Professor Margaret Gee for her precious assistance in the preparation of the manuscript and to Dr. Robert Hardin for his advice regarding the analysis of the data.

Special thanks are extended to all the participants of the present research for their cooperation and efforts.

The author is especially grateful to her parents and family for their love and continual encouragement during the course of her study abroad.

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INTRODUCTION

The growing number of elderly has increased interest in the relationships of nutrition to the aging process. The elderly are at risk of becoming malnourished for many reasons including altered food selection, declining health, increased use of medications, fixed incomes and immobility. However, it is difficult to distinguish between the effects of poor nutrition and the intrinsic effects of aging which may not be subject to modification.

Knowledge about aging process is incomplete because the techniques available for the measurement of early changes in physiological processes are limited. For example, there is much to be learned about how the sense of taste is altered with aging. Decreased taste sensitivity with advanced age has been reported by some, refuted by others. Most studies of the taste process has focussed on the measurement of taste thresholds, the measurement of the least concentration of a substance which a person can detect or recognize, usually one of the four primary tastes (salt, sweet, sour or bitter). The assessment of sensory response to the different tastes encountered in food that we eat (i.e. at the suprathreshold range) is a fruitful area for investigation.

Many studies suggest that the elderly are at risk for nutrient deficiencies because of poor dietary intake. Less energy and less total food are required by the elderly because both basal metabolic rate and degree of activity decline with increasing age. Low energy intake, particularly at the levels ingested by some elderly women, may be associated with poor intakes of many nutrients. Poor nutrient intake may affect the sense of taste; taste cells need an adequate supply of nutrients to function properly because taste cells are continually being replaced.

The present study was undertaken to examine several aspects of nutrition and taste perception including:

1. to what extent does suprathreshold taste perception of elderly free-living females differ from that of young free-living females.
2. to what extent does suprathreshold taste perception for aqueous systems differ from that for food systems.
3. to what extent are there identifiable diet-related problems in the elderly group as compared to the young group.
4. to what extent are there definable relationships between nutritional parameters and taste perception parameters.
5. to what extent do taste pleasantness response patterns vary with increasing concentrations of a taste stimulus.

Alterations in taste perception are significant because of their impact on food intake and perhaps dietary adequacy. One of the challenges for research today is to find ways of enabling older people to continue to live healthy and productive lives. It is possible that, by introducing more palatable foods into the diet of the elderly, their quality of life can be enhanced.

LITERATURE REVIEW

Little is known about the mechanism of the sense of taste. The human has a complex network of taste receptors located on the tongue, palate and pharynx (Henkin and Christiansen, 1967a and Lalonde and Eglitis, 1961). Of the four taste qualities (salt, sweet, sour and bitter) two, salt and sweet, are perceived most acutely on the tongue and the remaining two, sour and bitter, are perceived most acutely on the palate. The pharyngeal area does not have the same degree of sensitivity as the tongue and the palate (Henkin and Christiansen, 1967a). Chemical stimuli interact somehow with the taste receptors so that a message is conducted to the central nervous system by means of several cranial nerves (Altner, 1978).

The mechanisms of salt and sour tastes are somewhat similar. These tastes are both elicited by ions of dissociated compounds. Salt taste is attributed to anion-cation interactions and sour taste is attributed to hydrogen ion concentration (Altner, 1978). However, the compounds that generate sweet and bitter tastes do not dissociate and their molecular structures are often more complex and diverse (Shallenberger, 1970).

There are two theories about the effect of chemical stimuli on the taste receptors (Biedler, 1978). One theory is that the chemical stimuli are adsorbed to taste cell membranes producing a depolarization, which in turn leads to stimulation of a taste nerve ending across a synapse. The other theory is that chemical stimuli interact with nerve endings within the taste buds.

Anatomically the tongue is divided into two portions, anterior and posterior, and the surface of the tongue is covered by papillae. There are four types of papillae: filiform, foliate, fungiform and circumvallate (Biedler, 1978). The filiform papillae are small white papillae covering the entire surface of the tongue. These papillae have no known function in man (Altner, 1978). Covering portions of the anterior two-thirds of the tongue are a smaller number of fungiform papillae. These papillae are larger and red in color and each one may contain from one to eight taste buds. These taste buds are innervated by the chorda tympani branch of the facial nerve (Burton and Benjamin, 1971). The fungiform papillae are located in the anterior portion of the tongue and terminate at the sulcus terminalis, the V-shaped groove on the tongue. A gradual decrease in fungiform papillae with advancing age has been reported (Moses et al., 1967). Circumvallate papillae, found in the posterior one-third tongue, contain taste buds which are innervated by a branch of the glossopharyngeal nerve. The circumvallate papillae are more numerous and contain more nerve endings than the fungiform papillae. With advancing age the number of circumvallate taste buds has been found to decrease (Arey et al., 1935).The following changes have been documented to occur with advancing age: decreased number of papillae on the tongue; atrophy of taste buds and decreased number of taste buds (Arey et al., 1935). Therefore, there may be a resultant diminution in taste perception in the aged.

Artificial dentures also have an influence on taste perception. Individuals fitted with dentures often complain about a decreased ability to obtain flavor from food (Taylor and Dodu, 1963). Dentures cover that anatomical area which is most sensitive to the taste of bitter and sour. Henkin and Christiansen (1967b) demonstrated that thresholds for sour and bitter are elevated above normal when dentures has been in place for a short time and that these raised thresholds return to normal if dentures are removed. Thresholds for salt and sweet are not affected by dentures.

In the past most studies of the sense of taste have utilized measurements of threshold, i.e. measurements of the least concentration of a substance which a person can taste. A clear elevation of thresholds for saltiness and sweetness in the elderly has been observed (Baker, 1983; Balogh and Lelkes, 1961; Cooper et al., 1959; Greger, 1977; Greger and Geissler, 1978; Hinchcliffe, 1958; Moore et al., 1982; Murphy, 1979 and Weiffenbach et al., 1982). Although Grzegorczyk et al. (1979) and Hermel et al., (1970) found insignificant changes in salt threshold in the elderly, the data per se indicated that taste ability tended to fade with age. Compared to saltiness and sweetness some researchers (Balogh and Lelkes, 1961; Cooper et al., 1959; Murphy, 1979 and Weiffenbach et al., 1982) found that the sour threshold is less affected during aging. Yet Glanville et al. (1964) and Hermel et al. (1970) showed an increase in sour threshold. Effects of aging on thresholds for bitterness are more conflicting. Kaplan et al. (1965) reported that bitter taste sensation is unchanged with advancing age while Balogh and Lelkes (1961) found a decreased sensitivity to bitterness with age. However, some researchers (Cooper et al., 1959; Glanville et al., 1964; Hermel et al., 1970; Smith and Davies, 1973; Murphy, 1979 and Weiffenbach et al., 1982) reported an increased sensitivity to bitterness with increasing age.

In recent years more work has focussed on the measurement of taste perception in the suprathreshold range which depicts the range typical of foods people consume. Bartoshuk (1978) stated that measurement of taste perception in the suprathreshold range reflects an individual's taste sensation more accurately than thresholds. Some investigators (Byrd and Gertman, 1959 and Cohen and Gitman, 1959) found that at suprathreshold levels sensitivity to the four basic tastes in aqueous solutions was relatively unaltered in the aged. Taste perception at suprathreshold levels in a food model system has been evaluated. Murphy (1985) and Schiffman (1977) observed that the elderly subjects were less able to identify blended foods compared to the young while Stevens and Lawless (1981) did not find differences attributable to age. Elderly were also less able to discriminate various salt levels in tomato juice and gave lower taste intensity and preference ratings compared to young subjects (Little and Brinner, 1984). At suprathreshold levels the diminution of taste perception with age is still unclear.

Taste perception in the suprathreshold range is quantified by estimating how an individual's judgements of taste intensity change as the concentration of the stimulus changes. This is often assessed by ratio scaling or magnitude estimation which was developed by S.S. Stevens in 1957. Magnitude estimation allows the subject to employ any numbers he thinks appropriate to express the apparent magnitude of the intensity or pleasantness of the stimulus.

The power law has been used to describe the behaviour of human taste (Stevens, 1975). According to Steven's Power Law, the perceived magnitude is a power function of the stimulus magnitude. As a stimulus increases in intensity, taste sensation magnitude increases in the following way:

$$S = kM^B$$

where S = taste magnitude

M = stimulus magnitude

B = the power exponent

k = constant for the system chosen

If the exponent is 1 the reported sensation varies directly with the intensity of the stimulus. The power law defined the relationship between the intensity of the stimulus and the response so that the ratios of the numerical values can be used to indicate the actual change in the perceived stimulus magnitude. Several methods have been used to express the magnitude estimation data including medians, geometric means and arithmetic means (Moskowitz, 1977). Although no zero or negative estimates are permitted in using geometric means, at perceptible suprathreshold levels the geometric mean is still appropriate for magnitude estimation data (Marks, 1974 and Stevens, 1975). The data are usually plotted using log-log coordinates (Stevens, 1957). The graph of the power function then becomes linear and the exponent becomes the slope of the line.

For the elderly some researchers have found that intensities of certain tastes grow at a slower rate with concentration and that the psychophysical function becomes flatter. Using the magnitude estimation method, age-related declines in the psychophysical functions for the four basic tastes have been observed (Cowart, 1983 and Weiffenbach et al., 1986). The decline of taste sensation with aging is taste quality-specific. Hyde and Feller (1981) reported that the aging effect on suprathreshold taste intensity scaling was greatest for bitterness, less for sourness and least for sweetness and saltiness. Schiffman and Clark (1980) and Schiffman et al. (1981) found that the elderly females generated flatter psychophysical functions for amino acids and sweeteners compared to young females. However, Bartoshuk et al. (1986) did not find any significant age-related changes in suprathreshold sensation of the elderly using the magnitude matching method. Loudness of sound was used to match the taste intensity.

Bertino et al. (1982), Moskowitz et al. (1974) and Pangborn and Pecore (1982) observed that results obtained using model taste systems were different from those obtained using real foods. The measurement of taste perception for particular taste qualities and a particular set of conditions is useful in understanding the function of the sense of taste.

Investigations of the effect of age on taste preference are scarce. Laird and Breen (1939) reported an age-related change in preference of sweetness in pineapple juice for subjects over 50 years old. However, in other studies (Desor et al., 1975 and Enns et al., 1979) no age effects on sweet and salt preferences were found. Using the magnitude matching method, Cowart (1983) studied taste preference for the four basic tastes in six age groups. Age related changes in pleasantness ratings were only significant for sweetness. Murphy (1985) investigated the taste preference for salt, sweet and sour tastes in both aqueous and food systems. Significant age and medium effects were found for all three tastes. The elderly subjects found salt and sugar more pleasant at higher concentrations than did young subjects, regardless of the medium used. The elderly consistently rated sour aqueous solutions as less pleasant than did young subjects but they rated the sour beverages as more pleasant than did young subjects.

Lundgren et al. (1978) revealed four possible hedonic response patterns to increasing stimulus intensity. First, a monotonic decreasing hedonic response; second, a parabolic function; third, a monotonic increasing hedonic response; fourth, a horizontal line. Pangborn, (1970), Lundgren et al. (1978) and Trant and Pangborn (1983) were able to identify two or three distinctive hedonic responses among their subjects and illustrated that subjects could be classified according to their hedonic responses.

In some studies both taste intensity and taste preference at suprathreshold concentrations have been measured. Kocher and Fisher (1969) and Trant et al. (1981) demonstrated that hedonic and intensity responses exhibited different functions with stimulus concentration. It has been shown that perceived intensity responses are linear with increasing concentration but that hedonic responses are quadratic (Moskowitz, 1981 and Trant et al., 1981). If food is perceived as having a weak or inappropriate taste, this could lessen the enjoyment of eating and could be an important factor contributing to dietary inadequacies.

In a study of preschool children (Korslund and Eppright, 1967), subjects whose taste acuity was reported to be low were classified as tending to accept more foods and to exhibit more enthusiasm for these foods. The reverse was reported for subjects in whom taste acuity was reported to be high. Henkin et al. (1964) have studied patients with familial dysautonomia who have abnormalities of taste and smell. They have suggested that the lack of taste acuity observed in these patients and their obvious avoidance of food may be related. Birch (1979) showed that preference measurements were correlated with food intake patterns in preschool children. It is possible that measurements of taste preference can provide important information about eating behaviour.

To date experiments examining the relationship between dietary intake and sensory response have not established any significant relationship. Mattes (1985) studied the relationship between taste response and dietary intake in healthy adults. No significant correlations were obtained. Mattes-Kulig and Henkin (1985) evaluated the effects of taste distortion (dysgeusia) on dietary intake. The results showed that as the severity of dysgeusia increased, energy consumption of the patients significantly decreased. Indices of nutritional risk showed that many of these patients exhibited nutrient inadequacies.

Some of the nutrients reported to be consumed in marginally adequate amounts by the elderly are ones that could affect taste perception e.g. zinc, vitamin A and folacin.

Zinc is thought to play an important role in the taste process. Zinc deficient animals exhibited tastant-induced nerve changes, hyperkeratosis of lingual epithelium and keratotic degeneration of the taste bud (Osmanski and Meyer, 1969 and Catalanotto, 1977). Zinc is also found to be essential in protein synthesis (Prasad et al., 1971). Since taste buds are composed of rapidly dividing cells, the effect of zinc on taste buds could be related to its role in protein synthesis (Henkin et al., 1981). A zinc containing protein, gustin (Henkin et al., 1975), is believed to be necessary for the maintenance of normal taste bud function (Shatzman and Henkin, 1981). Shatzman and Henkin (1981) demonstrated that zinc therapy of a patient with proven hypogeusia elicited an increase in gustin levels and taste ability. Other researchers (Hambidge and Walravens, 1976; Henkin and Bradley, 1970; Henkin et al., 1971 and Schechter et al., 1972) have shown zinc supplementation to be effective in treating some taste abnormalities. Although taste dysfunction is an inevitable symptom of zinc deficiency (Hambidge et al., 1972), about two thirds of the patients with taste abnormalities are not zinc deficient (Henkin et al., 1981). Evidence for the relationship between impaired taste function and poor zinc status of elderly persons is lacking. Bales et al. (1986), Greger (1977), Greger and Geissler (1978), Greger and Sciscoe (1977) and Hutton and Hayes-Davis (1983) did not find correlations between measurements of zinc and detection and/or recognition thresholds for saltiness and sweetness. Zinc may play a direct role in the sensation of taste or an indirect role because zinc is involved in the synthesis of retinol binding protein, a transport protein for vitamin A (Henkin and Smith, 1972; Jacob et al., 1978 and Smith et al., 1974).

Vitamin A (retinol) is essential for maintaining the normal integrity of epithelial tissue (Wolbach and Howe, 1925). Human taste buds consist of modified epithelial cells (Gershoff, 1977) and have a short life span with a range of only three to thirty days (Biedler, 1978). Therefore, poor vitamin A status can slow the rate of normal differentiation of taste buds and may have a direct effect on the functioning of taste cells. A relationship between experimental vitamin A deficiency and abnormal sensation in the human has been reported (Hodges and Hodges, 1980 and Sauberlich et al., 1974). In addition Bernard et al. (1961) reported that rats depleted of vitamin A showed abnormal taste response to salt and quinine solutions. Administration of vitamin A resulted in rapid recovery of the response to salt but not to quinine.

Many researchers have reported dietary inadequacies among the elderly. Energy requirement decreases with age because of an age-related decrease in basal metabolic rate and a decrease in physical activity (Exton-Smith, 1972). Energy intakes reported in the literature for elderly women are usually even lower than recommendations (Garry et al., 1982; Guthrie et al., 1972; Kohrs, 1978; Leichter et al., 1978; Reid and Miles, 1977; Vir and Love, 1979 and Yearick et al., 1980). Although energy requirement is reduced for the elderly, the requirements for other essential nutrients do not concomitantly decrease. The Nutrition Canada report stated that the elderly were at risk for deficiencies for iron, folacin, thiamin, calcium and vitamin A. Other reports in the literature indicate that the elderly are classified as a vulnerable group for nutritional deficiencies. The reported nutrient intakes of free-living elderly women are summarized in Table 1.

It is evident that the elderly are at risk for nutrient deficiencies and also may have decreased taste perception. Whether changes in taste perception influence food intake and nutritional status of the elderly needs to be explored. In addition, the relationship of certain nutrients to the sense of taste requires further investigation. This study was undertaken to compare relationships between taste perception and dietary intake for elderly and young women.

Table 1: Nutrient intakes of free-living elderly women

Author	Age (yr)	N[1]	kcal	Protein (g)	Calcium (mg)	Iron (mg)	Vit.A (I.U.)	Thiamin (mg)	Ribo-flavin (mg)	Niacin (mg)	Vit.C (mg)	Others/remarks	
Garry et al., 1982	60+	166	(33)* 1653	(3) 67	(43) 603	(5) 7.5	(10) 3015	(13) .75	(6) .83	(0) -	(7) 45	Folic acid:(84), Zinc :(88), Vit.B_{12} :(39) Vit.B_6 :(86%)	* % of subjects whose intakes below RDA.
Yearick et al., 1980	74	75	1586	70	707	10.8	6537	1.16	1.51	13.6	102		
Vir &		27	1765	52	711	8.6	995mcg	.74	.99	-	29	Vit.B_6: 0.91mg	
Love, 1979		11	1772	59	719	9.9	884mcg	.82	1.19	-	53	Vit.B_6:1.1mg	
Kohrs et al., 1978a	59+	52	1619	62	811	10.5	10648	1.0	1.70	12.0	124		
Kohrs et al., 1978b	59+	70	(70)*	(113)	(82)	(131)	(120)	(102)	(115)	(95)	(166)	* estimated mean % of RDA	
Leichter, et al.,	74.3	53	1449	62	671	9.4	5230	.90	1.80	12.1	87	single women	
1978	69	23	1108*	51	379*	7.7	3979	.60*	0.90*	11.7	79	married women; * values significantly lower than those of the single women	
Brown et al., 1977	77	14	1633	60	570	10.5	5439	.96	1.28	12.2	122		
Reid & Miles, 1977	65-85	50*	1593	58	644	9.4	5002	.91	1.45	12.9	72	* include 11 men	
Guthrie et al., 1972		69	1347	56	493	9.6	2999	.90	1.20	-	64		
Joering, 1971	72	92	1135	52	475	8.5	5414	.82	1.10	10.0	55		
Nutrition Canada, 1973	65+	818	1530	54	619	10	1008R.E.	.85	1.47	21.0N.E.	87	Total Folate: 130mcg	

[1] number of subjects

METHODOLOGY

1. Selection of Subjects

Two groups of subjects, elderly females (70 to 79 years) and young females (20 to 29 years), were selected from the greater Edmonton area according to the following criteria:

(1) Caucasian females, free-living residents of the greater Edmonton area for over six months

(2) English speaking and willing to participate in the study

(3) Ambulatory with no known history of serious metabolic diseases (in the case of young females, individuals who were pregnant or breast-feeding were excluded)

(4) Not following a special therapeutic modified diet.

A random sample of individuals was obtained by the Alberta Department of Hospitals and Medical Care from names of appropriate individuals registered in the Alberta Health Care Insurance Plan. In each group 176 individuals were anformed of the study by letter; it was hoped that at least thiry subjects for each group would be recruited. The letter requesting participants for the study appears in Appendix 1. Individuals who indicated an interest in the study were interviewed by the researcher. A questionnaire was used to determine if each individual was suitable for the study (Appendix 2, Part I). In the 70 to 79 year old group, 31 individuals (18%) indicated an interest in the study and 17 (10%) were enrolled in the study. In the 20 to 29 year old group, 17 women (10%) indicated an interest in the study and 9 (5%) were enrolled in the study.

In order to recruit additional individuals for the study it was necessary to use other methods of obtaining subjects. Volunteers were obtained by contacting friends and several organizations, including the Strathcona Place Society, the Society for Retired and Semi-Retired and the YWCA. Contact procedures were similar to those outlined above; the letters requesting participants appear in Appendix 3. The questionnaire was used to collect information about the suitability of the subject for the study as before. In the 70 to 79 year old group, 13 additional subjects were enrolled for a total of 30 subjects. In the 20 to 29 year old group, 21 additional subjects were enrolled for a total of 30 subjects. The questionnaire (Appendix 2, Part II) was completed with each subject to provide the researcher with additional information such as socioeconomic status, drug usage, smoking habits, alcohol consumption pattern and further demographic data.

Five appointments of one to two hours each were made with each subject to enable the researcher to collect quantitative data about taste perception and dietary intake. Data were collected at the home of the subject, at The University of Alberta in the Department of Foods and

Nutrition, at the Strathcona Place Society or at the Society for Retired and Semi-Retired. The researcher collected all data from the subjects between March and November, 1985.

2. Assessment of Taste Perception

The method of magnitude estimation (ME) was used to assess taste perception. Using ME each subject is allowed to assign any number (not negative numbers) to a series of sensory stimuli so that the ratios of the numbers assigned reflect the ratios of the sensory perception values. A fixed standard and fixed modulus method was used (Moskowitz, 1977). The first sample presented was a reference sample within the usual physiological range; this sample had previously been assigned a number and was used as a reference for the series of sensory stimuli to be tested. Each subject was introduced to the method of ME by means of a training session using lines of various lengths and pieces of paper of various shapes (Appendix 4). The purpose of this training session was to guide the subject in the use of numbers and particularly ratios for quantifying perceptual differences and degrees of preference.

In this study taste perception was tested for two taste qualities, sour and salty. For the sour taste quality the reference sample was 12 mM citric acid (CA); for the salt taste quality the reference stimulus was 80mM sodium chloride (NaCl). A rating of 10 was pre-assigned to each reference sample. The reference samples were chosen at concentrations above the reported threshold levels for the elderly (Bartoshuk et al., 1986).

Taste perception was tested for the two taste qualities (sour and salt) using aqueous solutions as well as simple foods. In each series the taste quality concentrations ranged to suprathreshold levels. For the sour modality, six aqueous solutions were prepared from CA (Allen and Hanbury®) and double distilled deionized water in the following concentrations: 3, 6, 12, 18, 24 and 36mM CA. The concentration of each solution was determined by titrating the solution to pH 8 with 0.1 N sodium hydroxide (Ruck, 1956). For the salt taste quality, six aqueous solutions were prepared with double distilled deionized water in the following concentrations: 20, 40, 80, 160, 320 and 640mM NaCl. The analytical composition of the salt used appears in Appendix 5. The concentration of each NaCl solution was determined using the Volhard Chloride method (Hillebrand and Lundell, 1953). The concentration of each solution was within a 10% limit of the target value.

The simple food systems were an apple drink for the sour taste quality and a chicken soup for the salt taste quality. A low acid apple drink was obtained from General Foods Ltd. with the following characteristics: 0.063% (wt/vol) malic acid, Brix value = 10.7^{0}. A low sodium chicken soup powder was obtained from Stafford Food Ltd. with an initial concentration of 0.003% (wt/vol) NaCl. To ensure that a clear broth was used the soup was strained. The simple food systems were prepared as follows. For the sour taste quality, CA was added to the standard low acid apple drink to obtain concentrations of 3, 6, 12, 24 and 36mM CA. For the salt taste quality, NaCl was added to the standard strained low sodium chicken soup preparation to obtain concentrations of 20, 40, 80, 160, 320 and 640mM NaCl. The CA and NaCl concentrations were verified and adjusted by the methods used for aqueous solutions. The samples were prepared in batches (1500 mL of the reference samples and 500 mL of the other concentrations). The stock solutions were dispensed in 20 mL glass vials with screw caps and stored at -15^0C for use within three weeks.

For evaluation by subjects, sample temperature was controlled. Aqueous solutions were at room temperature (20 ± 3^0C) while food samples were evaluated at temperatures normally consumed. Apple drink samples were at 12 ± 2^0C. To maintain the apple drink samples at the appropriate temperature, the samples were immersed in a water bath (12 ± 3^0C) to a depth of one cm. Soup samples were maintained in a closed water bath at 60 ± 5^0C. The following equipment was used to regulate the temperature of the sample: Ice Pak®, aluminum tray (23x33 cm), hot tray (Salton Hotray®), two Corning Ware® casseroles (900 mL), thermometer.

Subjects were tested individually. Each subject was asked to avoid smoking, eating or drinking anything except water, for at least one hour prior to the tasting session. The pH of each subjects' saliva was determined at the beginning of each taste session using pH paper (paper for the range pH 3 to 8 - Micro Essential Laboratory). Subjects were allowed to remove their dentures if they wished before each tasting session.

The procedure for tasting was standardized as follows. Samples were presented to each subject as 10 mL liquid samples in 30 mL disposable plastic Medicups®. Each sample was labelled with a three-digit random number. A "sip and spit" method was used. Each subject held the entire sample in the mouth for three seconds, then expectorated. The intensity and pleasantness of the sample were rated numerically and the researcher recorded the rating on the scorecard, (see Appendix 6 for a sample scorecard, Appendix 7 shows the instructions given for rating samples). After tasting each sample, the mouth was rinsed with water (twice if necessary) to wash away the aftertaste. Double distilled deionized water was used for rinsing and was available for the subject ad libitum.

Taste perception data for each subject were collected as follows. At each tasting session, the subject evaluated six concentrations of the test taste quality in aqueous solution, followed in 10 to 15 minutes by six concentrations of the same taste quality in the food system. There was a minimum of 20 seconds between the evaluation of each tastant. Using a modification of Hyde and coworkers' (1981) sequence order the six test solutions were presented in a partially randomized order so that no two consecutive samples differed in concentration by greater than four-fold (Appendix 8). The reference samples were introduced twice; once before the first unknown and again before the fourth unknown to remind the subject of the intensity and pleasantness of the reference. A hidden reference sample was also presented for evaluation. Each sample was evaluated on three different days. Half of the subjects evaluated the sour taste quality first while the other half evaluated the salt taste quality first.

The subject profile questionnaire (Appendix 2, Part II) provided information about factors influencing taste perception such as use of dentures, use of table salt, smoking habits and alcohol consumption patterns.

The raw data for magnitude and pleasantness estimates of each subject were tabulated and reordered by the computer for statistical analyses. Personal information was coded for correlation purposes.

3. Assessment of Dietary Intake

Dietary intake for four days was assessed for each subject. The method used was a combination of dietary recall and food record. The researcher, trained in the Nutrition Canada techniques of quantitative dietary assessment using food models, collected all the data. Instructions for conducting dietary interviews are presented in Appendix 9. Dietary data were collected at the second, third and fifth interviews with each subject. Representative intakes for three week-days and one week-end day were obtained.

At the second interview with the subject, a twenty-four hour recall of food intake was obtained. A sample form for collecting a 24-hour dietary recall appears in Appendix 10. Each subject was asked to recall, in chronological order, all foods and beverages consumed the preceding day, starting when the subject awakened. Food models, constructed according to Nutrition Canada specifications were used to estimate serving sizes. Methodology for completing food records was then carefully explained and a food record form (Appendix 11, Part 1) was given to the subject to complete for the day preceding their next interview. A sample food record (Appendix 11, Part 2) was left with the subject as a guide. At the next visit (the third interview) the record was reviewed with the subject to clarify all details. At the fourth interview food records for two days were given to the subject to be completed on the two days preceding the final meeting with the subject. A total of three days of food records was collected. For two of the young subjects additional food records were collected because the subjects' eating patterns were irregular and more data were required to evaluate the usual intake. For one subject the dietary intake for six days was assessed; for the other subject the dietary intake for seven days was assessed. The researcher reviewed each food record with each subject. The initial 24-hour recall was used as a cross check for completeness of information. Skilled probing by the researcher helped to ensure completeness of the assessment of dietary intake. Additional information was obtained e.g. the use of vitamin/mineral supplements. If vitamin/mineral supplements were used for a period exceeding six months, the following information was obtained about each of the supplements: brand name, nutrient composition, intake frequency and dose. The subject profile questionnaire (Appendix 2, Part II) provided additional information about food preparation and food habits.

The computation of daily nutrient intake proceeded as follows. The researcher coded each item using standardized techniques developed in the Department of Foods and Nutrition. The food intake data were transferred to computer tape for the computation of nutrient intake by the main-frame computer (University of Alberta). Daily intakes were calculated for energy, protein, fat, cholesterol, total carbohydrate, dietary fiber, sugar, starch, thiamin, riboflavin, niacin, vitamin B_6, vitamin B_{12}, folacin, ascorbic acid, vitamin A, vitamin D, calcium, phosphorus, iron, potassium, sodium and zinc.

The nutrient data base was the Canadian Nutrient File (1983), a data base derived from Handbook No. 456 of the United States Department of Agriculture (Adams, 1975) into which has been incorporated Canadian food composition data for a total of over 3000 food items. Values for dietary fiber and cholesterol were added to the nutrient data base from Southgate's tables (Paul and Southgate, 1978) and from the Nutrition Coding Center, Minneapolis (Feeley et al. 1972). Values for zinc were added to the tape from various sources: Revised Agricultural Handbook No. 8 (Watt and Merill, 1975), Murphy et al. (1975), Freeland-Graves et al. (1980), Freeland and Cousins (1976), Lawler and Klevay (1980), McNeill et al. (1985). Computer programs converted volumes of foods to mass and then calculated nutrients per day. Average nutrient intakes per day with and without vitamin/mineral supplements were computed for each subject. Mean nutrient daily intakes expressed as nutrient densities (intakes per 1000 kcal) were also calculated for each subject.

Daily intakes of foods classified according to food groups were also obtained. The ten food groups used for the Nutrition Canada survey (1976) (developed by USDA) formed the basis for the food grouping system. The ten food groups were 1) dairy products 2) meat, poultry, fish and eggs 3) cereal products 4) fruit and fruit products 5) vegetables 6) fats and oils 7) nuts and legumes 8) foods primarily sugar 9) beverages and soft drinks 10) miscellaneous (including mixtures of food groups, soups, condiments and items not classified elsewhere).

Nutrient intakes were also assessed for the probability of risk that the observed intake is inadequate for the described individual (Anderson et al., 1982). A software package designed by Dr. G.H. Beaton, University of Toronto, was used for this purpose on an Apple IIe micro-computer

4. Anthropometric Measurements

The following anthropometric measurements were collected for each subject: height, weight, triceps skinfold thickness, arm circumference and elbow breadth. One set of equipment was used throughout the study to obtain anthropometric measurements including the following: a portable spring scale ("SECA" distributed by Precision Scale Ltd Co.), Lange skinfold calipers, metal calipers, steel measuring tape. When anthropometric measurements were taken, each subject wore light indoor clothing with shoes removed.

Relative body weight (RBW) was determined from the following information: height, frame size and desirable weight tables prepared by the Metropolitan Life Insurance Company (Grande and Keys, 1980). Height was measured as follows. The subject stood against a flat vertical surface, with the heels, buttocks, shoulders and head against the vertical surface. A right angle metal headpiece, levelled horizontally was brought to the crown of the head and a mark placed on the vertical surface. The distance from the floor to the mark was measured with the metal tape. Frame size categories were those specified in "The 1983 Metropolitan Height and Weight Tables" and were determined as follows. The greatest breadth across the elbow joint was ~~measured~~ with a sliding caliper with the arm in the following position: arm bent so the angle at the elbow forms 90^0 with the fingers pointing up and the dorsal part of the wrist toward the researcher. The triceps skinfold measurement was taken over the triceps muscle halfway between the elbow and the acromial process of the scapula. The skinfold was grasped along the posterior midline of the left arm at the point one centimeter above midpoint.

Mid-arm muscle circumference was determined as follows. Left upper arm circumference measurement was taken with a steel tape halfway between the tip of the elbow and the acromial process of the scapula, with the arm hanging relaxed. Mid-arm muscle circumference was calculated using the formula: arm muscle circumference = arm circumference $- \pi$ x triceps skinfold thickness, where all measurements are in millimeters.

Percentage of standard values were calculated for the triceps skinfold measurement, mid-arm circumference and for the mid-arm muscle circumference measurement using as standards the sex and age specific 50th percentile values for the Canadian population (Jette, 1983).

Theoretical basal energy requirement (BER) was calculated for each subject using the Benedict-Harris equation:

$$\text{BER for females} = 655.10 + 9.56(W) + 1.85(H) - 4.68\,(A)$$

(W=weight in kg; H=height in cm; A=age in yr)

The protocol for data collection appears in Table 2.

The research proposal was reviewed and accepted by the Ethical Review Committee on Human Research. A sample of a consent form from the participants is shown in Appendix 12.

Table 2: Protocol for data collection

Interview		Taste Perception Evaluation	Dietary Assessment
1	signing of consent form, complete questionnaire, orientation to method of magnitude estimation	taste quality I	
2		taste quality I	24-hour recall; instruction on completing food record
3		taste quality I taste quality II	review food record (one-day)
4	taking anthropometric measurements	taste quality II	
5	present token of appreciation	taste quality II	review food records(two-days)

5. Data Analyses

5.1 Taste Perception Data

The method of magnitude estimation (ME) was used for the quantification of taste intensity perception and taste preference. Traditionally zero ratings are not allowed in the method of magnitude estimation. Occasionally, however, zero ratings can be given. In this study zero ratings were replaced by a number determined by multiplying by 0.1 the lowest estimate ever given by that subject for an intensity or pleasantness rating of that specific tastant (Moskowitz, 1970). For intensity measurements, six of the 4320 intensity estimates were zero (ratings given by two of the elderly subjects). For pleasantness measurements, 40 of the 4320 estimates were zero (ratings given by three elderly subjects and one young subject).

5.1.1 Intensity data

For each subject (N=60) taste intensity responses were examined for six stimulus concentrations for each of the two taste qualities (sourness, saltiness) in each of the two systems (aqueous, food). Thus for sourness the following citric acid concentrations: 3, 6, 12, 18, 24 and 36mM are equivalent to -2.5, -2.2, -1.9, -1.8, -1.6 and -1.4 in log values; for saltiness the following sodium chloride concentrations: 20, 40, 80, 160, 320 and 640mM are equivalent to -1.7, -1.4, -1.1, -0.8, -0,5 and -0.2 in log values. Magnitude estimates were transformed to logarithms to linearize the relationships for data analyses. Since there were three responses per subject for each intensity measurement, single mean values of each subject were used in the estimation of mean values of each of the two age groups for statistical analyses. The mean values presented in the tables are geometric means calculated using antilogarithms of the log intensity estimates. For each concentration of each taste quality in each system, log intensity estimates were compared between young and elderly groups using analysis of variance (ANOVA). At each concentration of each taste quality for in each age group, differences of log intensity estimates between the aqueous and food systems were determined by ANOVA. The intensity measurements of all six concentrations were used in ANOVA to determine the interaction effects of concentration with age or medium.

Coefficients of variation were calculated to examine the consistency in intensity response ratings for each of the six concentrations. The test for homogeneity of variance was used to determine whether the variances were homogeneous within groups.

Slopes and intercepts for the regression of taste intensity on concentration were computed for each subject for each taste quality of each system. For each of the 60 subjects four slopes of individual linear regression of taste intensity on concentration were computed i.e. one value for each set of tastants: sourness in aqueous and food systems and saltiness in aqueous and food systems. The slope of each line was used as an index of taste perception. Slopes and intercepts were also computed using normalized values (i.e. normalization of the magnitude estimates of intensity to the modulus of 10 for the reference concentration). However, the conclusions were essentially the same as for the non-normalized data and therefore the results presented are from analyses using non-normalized data.

5.1.2 Pleasantness Data

Statistical analyses for pleasantness data were the same as for the intensity data except that regression analyses (i.e. taste pleasantness on concentration) were not computed. For each subject an index of hedonic response was calculated as the absolute difference between the highest and lowest log pleasantness ratings of the six concentrations for each taste quality in each system.

5.2 Dietary Data

The intakes of the 23 nutrients for each of 60 subjects (30 elderly and 30 young) were assessed for each of four days. The nutrient intake value per subject was computed by averaging across the intake of the four days.

Vitamin/mineral supplement intake was also assessed for each subject. The nutrient intake values with and without supplements were compared between the young and elderly groups using the Student's t-test. For each subject an overall index of nutritional risk was calculated as the average of the percent risk of deficiency computed according to the software package "Probability Assessment of Nutrient Intake" by G.H. Beaton for each of twelve nutrients (i.e. protein, thiamin, riboflavin, folacin, vitamin B_6, vitamin B_{12}, vitamin A, vitamin D, ascorbic acid, calcium, iron and zinc).

5.3 Relationships between Taste Perception and Dietary Intake Data

The relationships between taste perception data and percent risk of nutrient deficiency were graphically presented using the scatterplot technique (Cleveland and Kleiner, 1975).

Pearson correlation coefficients were calculated between dietary intake data and taste parameters. Partial correlation coefficients were calculated between the dietary intake data and taste parameters controlling for age, weight and kilocalories when necessary.

Multivariate analyses (canonical correlations) were conducted to evaluate interrelationships among dietary intake variables with taste perception data.

The subjects were classified according to specified levels for the following variables: income, level of education, wearing of dentures, eating alone or with others, alcohol intake and smoking habits. The resulting groups were subjected to ANOVA to determine relationships between the variables and dietary and taste perception data.

Data were analysed using programs from: Statistical Package for the Social Sciences (SPSS^x User's Guide, 1983), Michigan Interactive Data Analysis System (MIDAS by Fox and Guire, 1976) and Interactive Statistical Graphics Package (Chenier, 1980).

RESULTS

1. Characteristics of the Subjects

Table 3 shows the characteristics of the young and elderly groups. Both groups were comprised of thirty women; the mean age of the elderly subjects was 73.7 years while that of the young subjects was 24.3 years. Statistical analyses revealed that the mean height and weight of the two groups were significantly different. The elderly group was significantly shorter ($p<0.01$) and heavier ($p<0.001$) than were the young subjects. The mean relative body weight was 119 percent for the elderly group and 100 percent for the young group. Relative body weight (RBW) was calculated by using desirable weights from Metropolitan Life Insurance Tables (Grande and Keys, 1980). The relative body weights of the individual subjects revealed that the number of women classified as overweight, with a RBW of over 120 percent, was greater in the elderly group (37 percent) than in the young group (18 percent).

Anthropometric measurements revealed that the mean triceps skinfold thickness and mid-arm circumference measurements were significantly greater ($p<0.001$) for the elderly group than the young group. Compared to reference values for the Canadian population, the mean triceps skinfold thickness measurements were 128 percent of standard for the elderly group and 99 percent of standard for the young group. Mid-arm muscle measurements were 94

Table 3: Characteristics of the young and elderly groups

Characteristics	Young	Elderly
Number of subjects	30	30
Age (years)	24.3 ± 0.5[1]	73.7 ± 0.5
Height (cm)	164 ± 1.3	159 ± 1.1**
Weight		
kg	58.2 ± 1.3	69.0 ± 2.5***
RBW[2]	100 ± 2.2	119 ± 3.4***
MAC[3]		
cm	26.0 ± 0.5	30.1 ± 0.7***
% of Standard MAC	94.8 ± 1.7	101.4 ± 2.5*
TSF[4]		
mm	19.8 ± 1.2	26.9 ± 1.3***
% of Standard TSF	99.2 ± 6.0	127.9 ± 6.1***
MAMC[5]		
cm	19.8 ± 0.2	21.8 ± 0.5***
% of Standard MAMC	94.0 ± 1.1	94.6 ± 1.9

[1] mean ± standard error of the mean

[2] Relative Body Weight

[3] Mid-Arm Circumference

[4] Tricep Skinfold Thickness

[5] Mid-Arm Muscle Circumference

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively

and 95 percent of standard for the elderly and young, respectively.

Table 4 presents subject profile data collected from the questionnaires. Socioeconomic aspects of the study groups and some variables affecting taste perception and dietary intake are presented. In addition, Table 4 describes the vitamin/mineral supplements used by the two age groups. The proportion of subjects consuming vitamin/mineral supplements was 47 percent for the elderly and 43 percent for the young. Among the supplement users in the elderly group, 57 percent took only one supplement while 14 percent took five or more supplements daily (one subject took nine). Among the users of vitamin and mineral supplements in the young group, 46 percent took only one supplement while 15 percent took three supplements daily. The type of vitamin/mineral supplement most frequently consumed was the single nutrient product for both age groups; vitamin E for the elderly and vitamin C for the young. Medications taken by subjects in this study included antihypertensive agents, diuretics, analgesics, laxatives and oral contraceptives. Of the elderly, seven subjects were taking more than one drug. The drugs most frequently used were cardiovascular drugs for the elderly and oral contraceptives for the young. Seven elderly subjects were using cardiovascular drugs and nine young subjects were using oral contraceptives.

Table 4: Subject profile data

	Young[1]	Elderly[1]
Age (years)	20-29	70-79
Education		
up to Grade 6	0	4
Grade 7 to Grade 12	0	13
Career Preparation	2	5
Post-Secondary	28	8
Income (self and spouse)		
< $14,999	10	17
> $15,000	20	10
not released	0	3
Smoking Habit		
never	26	28
light (1 cigarette/day)	0	1
medium (12 cigarettes/day)	3	1
heavy (25+ cigarettes/day)	1	0
Alcohol Consumption		
none	6	11
occasional	22	19
regular (1 time/day)	1	0
frequent (>1 time/day)	1	0
Denture Wear		
none	30	9
partial	0	4
upper or lower arch	0	7
both arches	0	10
People Eat Meal With		
alone	2	14
one other person or more	28	16
Salt Use		
none	24	17
small	6	11
fair	0	2
a lot	1	0
Vitamin and Mineral Supplement Use		
regular daily use (%)[2]	43	47
irregular use (%)	7	10
Product use:		
single nutrient product(%)[3]	44	66
multiple vitamin(%)	30	24
multiple vitamin+minerals(%)	26	10

[1] n=30
[2] percent of the group
[3] percent of the total product use

2. Taste Perception

2.1 Taste Intensity Data

2.1.1 Age Differences

The slopes and intercepts of the intensity functions for sourness and saltiness for the young and elderly groups are shown in Table 5. Significant age-related differences were found from ANOVA analysis.

For sourness the slopes of the taste functions in aqueous and food (apple drink) systems showed significant ($p<0.001$) age-related differences. For the elderly, the slopes of the taste functions for sourness in aqueous and food systems were significantly flatter than the slopes of the young group.

Geometric means of intensity estimates for each of the concentrations of citric acid (CA) are presented in Table 6. For the CA aqueous solutions the elderly group perceived the two lowest concentrations (3mM, $p<0.001$ and 6mM, $p<0.01$) to be significantly more intense than did the young subjects. However, the elderly group rated the CA aqueous solutions at higher concentrations (18, 24 and 36 mM CA) significantly less intense ($p<0.01$) than did the young subjects. The same pattern of age differences was also observed in the sour food systems. The elderly subjects judged the lower concentrations (3mM, $p<0.01$; 6mM, $p<0.01$) of the apple drink samples to be significantly stronger and the higher concentrations (24mM, $p<0.05$; 36mM,

Table 5: Mean slope and intercept values of sour and salt taste qualities for the young and elderly groups

Taste Quality		Young[1]	Elderly[1]
Sourness:			
Aqueous	Slope	0.77 ± 0.05	0.47 ± 0.04***
	Intercept	2.54 ± 0.11	1.96 ± 0.08***
Food[2]	Slope	0.60 ± 0.05	0.33 ± 0.04***
	Intercept	2.15 ± 0.09	1.64 ± 0.08***
Saltiness:			
Aqueous	Slope	0.71 ± 0.04	0.50 ± 0.04***
	Intercept	1.79 ± 0.05	1.59 ± 0.05**
Food[3]	Slope	0.50 ± 0.04	0.42 ± 0.05
	Intercept	1.58 ± 0.04	1.50 ± 0.04

[1] n=30

[2] apple drink

[3] chicken soup

,* significant at $p < 0.01, 0.001$, respectively

Table 6: Geometric means of intensity estimates for different concentrations of citric acid for the young and elderly groups

Citric Acid (mM)	Aqueous Young[1]	Aqueous Elderly[1]	Food Young[1]	Food Elderly[1]
3	4.2	6.1***	4.6	6.7**
6	6.4	8.3**	6.3	8.2**
12	12.6	11.3	9.8	10.0
18	15.1	12.6**	11.7	10.7
24	20.7	16.1**	15.0	13.0*
36	27.2	20.1**	20.6	15.6**

[1] n=30

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively

$p<0.01$) to be significantly less intense than did the young subjects. Figure 1 presents the intensity functions (log estimates) for sourness in aqueous and food systems for both age groups. For sourness ANOVA of the log intensity estimates did not show any significant main effect for age, but for both aqueous and food systems significant ($p<0.001$) age x concentration interactions were found.

For the elderly subjects the slope of the taste function for NaCl aqueous solutions was significantly lower than that of the young subjects (Table 5). However, for saltiness in the food system (chicken soup), no significant age difference was observed.

Geometric means of the intensity estimates for the different concentrations of NaCl in each system appear in Table 7. For NaCl aqueous solutions the elderly subjects perceived the lower concentrations (20mM, $p<0.01$; 40mM $p<0.01$) to be significantly stronger than did the young subjects and the higher concentrations (160mM, 320mM and 640mM NaCl) to be significantly ($p<0.05$) less intense than did the young subjects. For saltiness in the food system, no significant differences were found in the geometric means of the intensity estimates of the young and elderly subjects. For log intensity estimates for saltiness, neither the aqueous solution nor the food system showed a significant main effect for age. The age x concentration interaction in NaCl aqueous solutions was significant at

Figure 1: Log intensity estimates of citric acid in aqueous and food systems

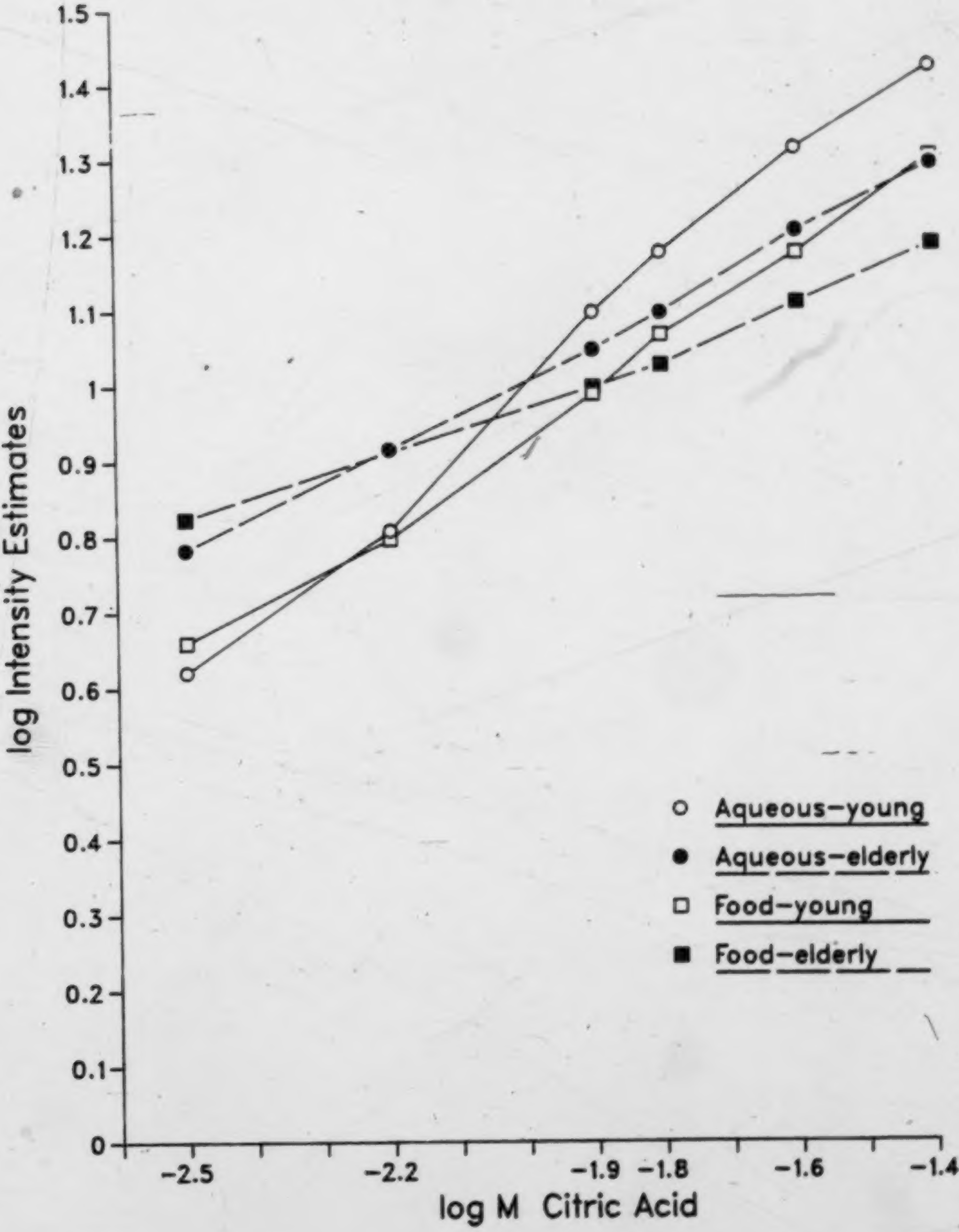


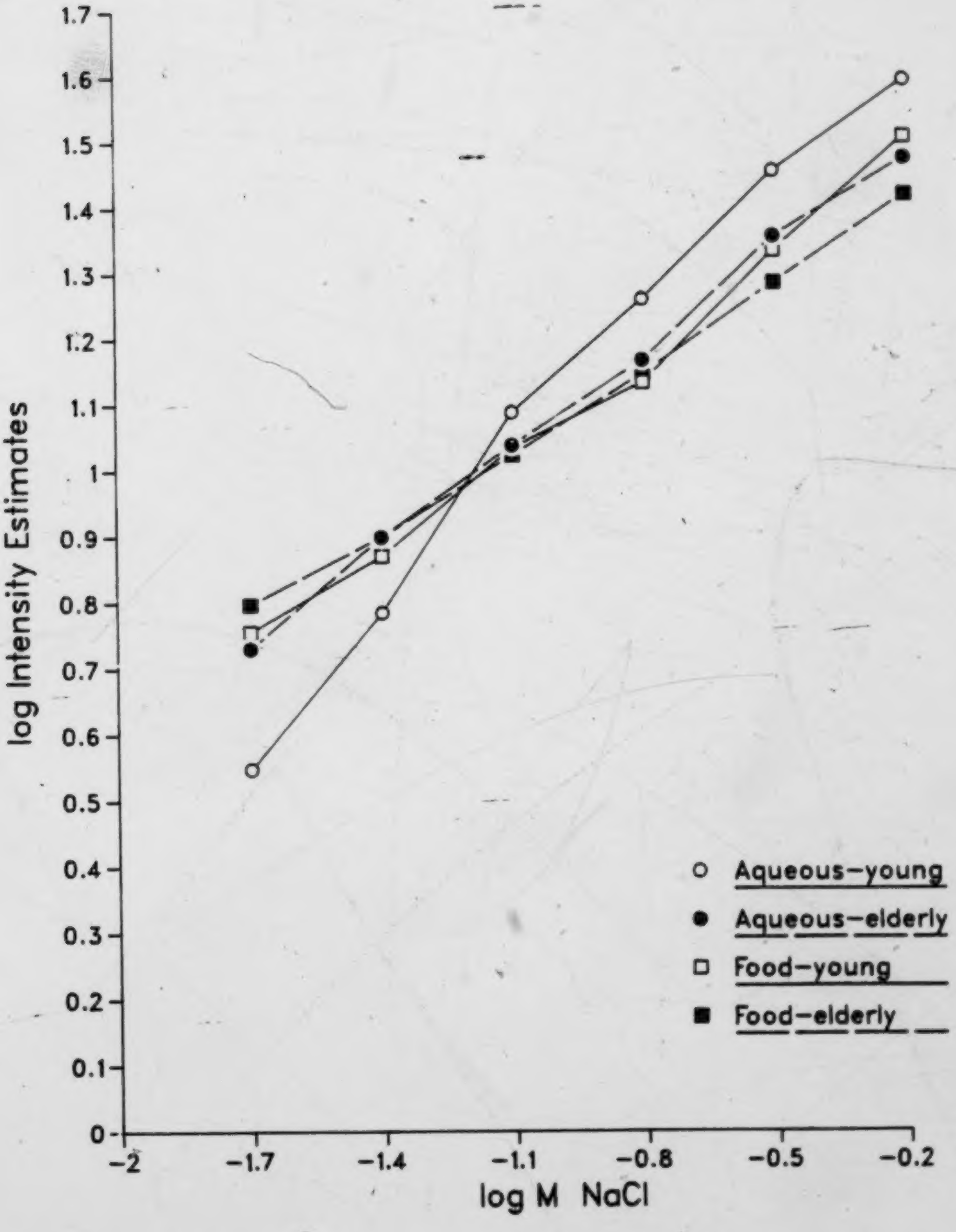
Table 7: Geometric means of intensity estimates for different concentrations of sodium chloride for the young and elderly groups

NaCl (mM)	Aqueous Young[1]	Aqueous Elderly[1]	Food Young[1]	Food Elderly[1]
20	3.5	5.4**	5.7	6.3
40	6.1	7.9**	7.4	7.9
80	12.4	11.1	10.9	10.6
160	18.3	14.9*	13.7	14.1
320	28.6	23.1*	21.8	19.5
640	39.6	30.2*	32.6	26.5

[1] n=30

*,** significant at $p < 0.05$, 0.01, respectively

Figure 2: Log intensity estimates of sodium chloride in aqueous and food systems



$p<0.001$ but no interaction effect was observed in the salt food system (Figure 2).

2.1.2 System Differences (Aqueous vs Food Media)

The mean slopes and intercepts of the taste functions for sourness and saltiness in aqueous and food systems are shown in Table 8. For both the young and elderly groups, the slopes of the taste functions for sourness in aqueous solutions were significantly ($p<0.05$) higher than those in food system. In addition, when the young and elderly subjects were combined as one group, the slope of the CA aqueous solution (.62) was also significantly steeper ($p<0.001$) than that of the food system (.46). At high citric acid concentrations (18mM, 24mM and 36mM) both the elderly and young subjects perceived the sour food systems to be significantly less intense than the aqueous solutions (Table 9). For sourness ANOVA did not show any significant main effect for medium in the elderly group. However, for sourness a significant ($p<0.01$) main effect for medium was observed in the young group. Medium x concentration interactions for sourness were significant ($p<0.001$) in both the elderly and young groups (Figure 1).

For saltiness in aqueous and food systems (Table 8), no significant differences were found between the slopes (.50 vs .42) of the taste functions in the elderly group. However, for the young group the slope for saltiness in

Table 8: Mean slope and intercept values of sour and salt taste qualities for aqueous and food systems

Taste Quality			Aqueous	Food[1]
Sourness:				
	Young[2]	Slope	0.77 ± 0.05	0.60 ± 0.05*
		Intercept	2.54 ± 0.11	2.15 ± 0.09**
	Elderly[2]	Slope	0.47 ± 0.04	0.33 ± 0.04*
		Intercept	1.96 ± 0.08	1.64 ± 0.08*
Saltiness:				
	Young[2]	Slope	0.71 ± 0.04	0.50 ± 0.03***
		Intercept	1.79 ± 0.05	1.58 ± 0.04***
	Elderly[2]	Slope	0.50 ± 0.04	0.42 ± 0.05
		Intercept	1.59 ± 0.05	1.50 ± 0.04

[1] apple drink for sourness; chicken soup for saltiness

[2] n=30

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively

Table 9: Geometric means of intensity estimates for different concentrations of citric acid for aqueous and food systems

Citric	Aqueous			Food		
Acid(mM)	Young[1]	Elderly[1]	Combined groups[2]	Young[1]	Elderly[1]	Combined groups[2]
3	4.2	6.1	5.0	4.6	6.7	5.5
6	6.4	8.3	7.3	6.3	8.2	7.2
12	12.6	11.3	11.9	9.8***	10.0	9.9***
18	15.1	12.6	13.8	11.7***	10.7**	11.2***
24	20.7	16.1	18.3	15.0***	13.0*	14.0***
36	27.2	20.1	23.3	20.6**	15.6*	17.9***

[1] n=30

[2] n=60

*,**,*** significant at $p < 0.05$, 0.01, 0.001, repectively, between systems within the same age group

aqueous solutions was significantly ($p<0.001$) higher than that in food system. When the data of the two age groups were combined for analyses, the slope of the taste function for the NaCl aqueous solutions was significantly (.60 vs .46 at $p<0.001$) greater than that for the food system. Table 10 shows that for the elderly group the geometric means of the intensity estimates for the six NaCl concentrations were not significantly different between two systems. However, for the young subjects saltiness in the food system with concentrations of 20mM and 40mM NaCl was perceived to be significantly more intense than in aqueous solutions; at concentrations of 160mM and 320mM NaCl, respectively, the food systems were perceived by the young as significantly less strong than in comparable aqueous solutions. ANOVA of log intensity estimates for saltiness did not show any significant main effect for medium in both groups. No significant medium x concentration interaction effect for saltiness was determined for the elderly subjects but for the young subjects the interaction was significant ($p<0.001$) (Figure 2).

2.2 Taste Pleasantness Data

2.2.1 Age Differences

Tables 11 and 12 present the geometric means of the pleasantness estimates for sourness and saltiness in both systems for both groups. Except for the highest CA

Table 10: Geometric means of intensity estimates for different concentrations of sodium chloride for aqueous and food systems

NaCl	Aqueous			Food		
(mM)	Young[1]	Elderly[1]	Combined groups[2]	Young[1]	Elderly[1]	Combined groups[2]
20	3.5	5.4	4.4	5.7***	6.3	6.0**
40	6.1	7.9	7.0	7.4*	7.9	7.7
80	12.4	11.1	11.7	10.9	10.6	10.7
160	18.3	14.9	14.1	13.7***	16.5	13.9**
320	28.6	23.0	25.6	21.8**	19.5	20.6**
640	39.6	30.2	34.6	32.6	26.5	29.4*

[1] n=30

[2] n=60

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively, between systems within the same age group

Table 11: Geometric means of pleasantness estimates for different concentrations of citric acid for the young and elderly groups

Citric Acid (mM)	Aqueous		Food	
	Young[1]	Elderly[1]	Young[1]	Elderly[1]
3	11.6	9.6	6.6	7.6
6	10.5	10.0	8.1	8.7
12	7.6	8.6	9.4	9.8
18	6.5	6.8	10.2	9.5
24	4.5	5.9	9.3	8.7
36	3.1	4.7*	6.9	7.8

[1] n=30

* significant at $p < 0.05$

concentration (36mM) in aqueous solution which the elderly rated as significantly more pleasant than the young (Table 11), there were no significant age differences in pleasantness estimates for sourness in aqueous and food systems. The elderly subjects preferred the aqueous solution of 6mM CA concentration; the young subjects rated the lowest concentration of 3mM CA to be most pleasant.

Figure 3 shows the group functions of pleasantness estimates for sourness in each system. Figure 3 shows that the hedonic curve of the sour aqueous system for the elderly group exhibited a plateau at low concentrations (3mM to 6mM) while the curve for the young group showed a decreasing monotonic trend. For sourness in the food system, both age groups exhibited a parabolic relationship between pleasantness ratings and CA concentrations (Figure 3) and preferred the middle sour concentrations (12mM and 18mM).

For sourness in aqueous and food systems no significant main effect for age was found in pleasantness response. The age x concentration interaction for pleasantness was significant ($P < 0.001$) for sourness in aqueous solutions but not in the food system.

For saltiness in aqueous and food systems (Table 12) significant age differences in pleasantness estimates were found only at the 20mM and 160mM NaCl aqueous solutions. Compared to the young subjects who preferred 20 mM NaCl,

Figure 3: Log pleasantness estimates of citric acid in aqueous and food systems

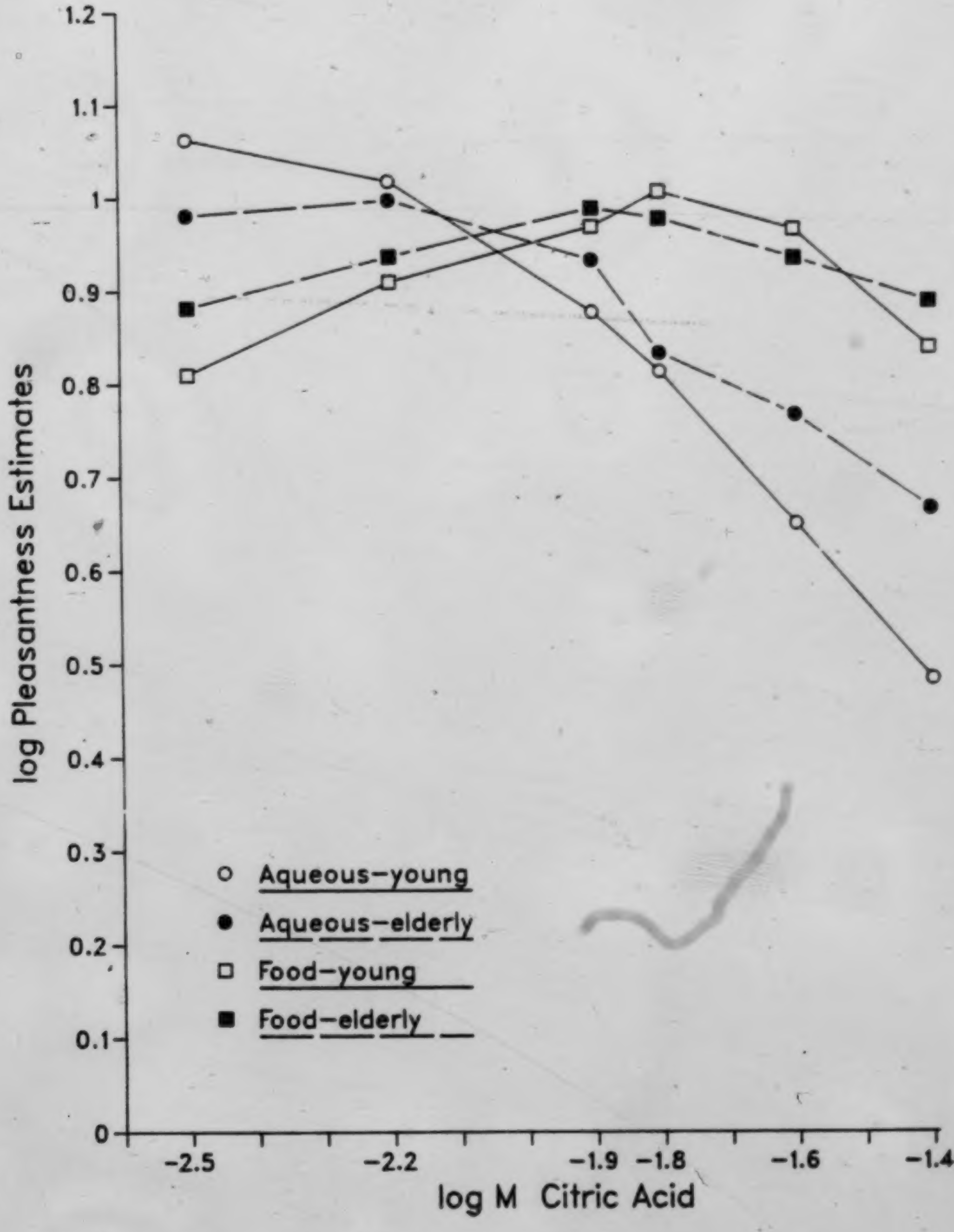


Table 12: Geometric means of pleasantness estimates for different concentrations of sodium chloride for the young and elderly groups

NaCl	Aqueous		Food	
(mM)	Young[1]	Elderly[1]	Young[1]	Elderly[1]
20	9.9	7.1**	6.3	6.8
40	9.6	8.5	8.1	8.3
80	8.7	9.9	10.6	10.5
160	6.6	9.1**	10.3	9.8
320	3.6	5.2	7.3	6.3
640	2.3	2.8	3.5	3.3

[1] n=30

** significant at $p < 0.01$

the elderly preferred the aqueous solutions with 80mM concentration of NaCl. For saltiness in the food system both age groups rated the 80mM NaCl samples to be most pleasant.

Figure 4 shows the group functions of pleasantness estimates for saltiness. For the aqueous system the shape of the hedonic curve generated by the elderly was parabolic with a break point at 80mM NaCl, while a decreasing trend in pleasantness estimates with concentration was observed in the young. For saltiness in the food system, both age groups showed a parabolic hedonic function which peaked at 80mM NaCl.

ANOVA of log pleasantness estimates did not show any significant main age effect for either the NaCl aqueous solutions or the food system. A significant ($p<0.01$) age x concentration interaction for pleasantness was found for saltiness in aqueous solutions (Figure 4) but not in the food system.

2.2.2 System Differences (Aqueous vs Food Media)

For both age groups, significant differences in sourness pleasantness ratings were found between aqueous and food systems (Table 13). Both elderly and young subjects judged the food systems (3mM and 6mM CA) as less pleasant than those of comparable aqueous solutions, but at CA concentrations of 18 mM or higher all subjects preferred

Figure 4: Log pleasantness estimates of sodium chloride in aqueous and food systems

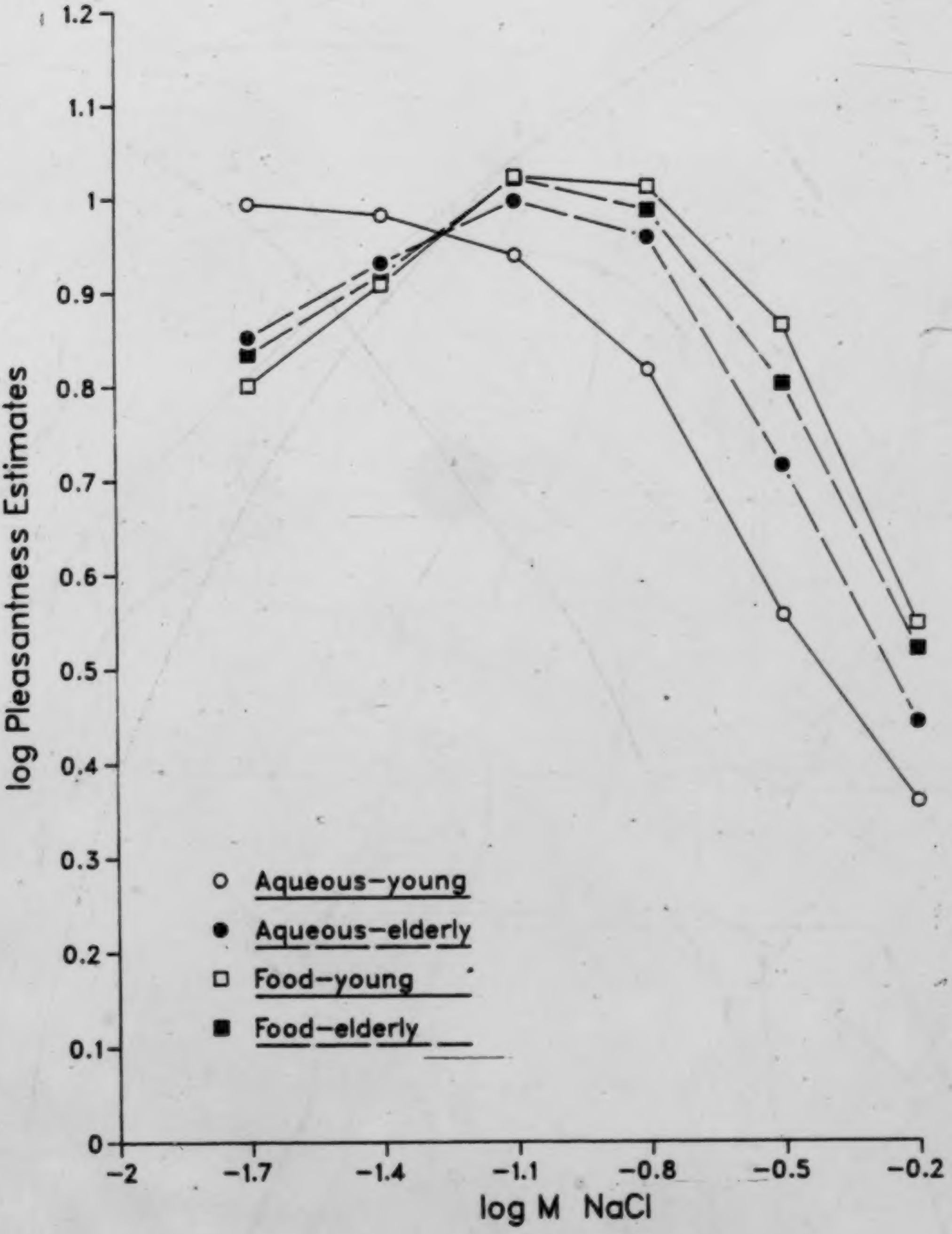


Table 13: Geometric means of pleasantness estimates for different concentrations of citric acid for aqueous and food systems

Citric	Aqueous			Food		
Acid (mM)	Young[1]	Elderly[1]	Combined groups[2]	Young[1]	Elderly[1]	Combined groups[2]
3	11.6	9.6	10.5	6.5***	7.6*	7.1***
6	10.5	10.0	10.2	8.1*	8.7*	8.3***
12	7.6	8.6	8.1	9.4*	9.8	9.5**
18	6.5	6.8	6.8	10.2***	9.5***	9.8***
24	4.5	5.9	5.1	9.3***	8.7**	8.9***
36	3.1	4.7	3.8	6.9***	7.8***	7.4***

[1] n=30

[2] n=60

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively, between systems within the same age group

the food system to the aqueous solutions. When the two age groups were combined for analyses, significant differences in pleasantness estimates for sourness attributable to medium were found for concentrations across the entire suprathreshold range. For both age groups, the hedonic responses for the sour aqueous system showed a decreasing monotonic trend with increasing concentrations while parabolic curves were elicited in the food system as CA concentration increased.

For pleasantness response to sourness, a significant main effect for medium was found in both the elderly ($p<0.05$) and young ($p<0.01$) groups. A significant ($p<0.001$) medium x concentration interaction for pleasantness of sourness was also observed in both age groups (Figure 3).

Table 14 presents the pleasantness estimates for saltiness in aqueous and food systems. For the elderly group no significant medium differences in pleasantness estimates were observed. However, for the young group, significant differences in pleasantness estimates of saltiness between the aqueous solutions and the food system were found for NaCl concentrations ranging from 20mM to 320mM. For both NaCl aqueous and food systems the elderly preferred 80mM NaCl. The young subjects preferred a higher NaCl concentration in the food system (80mM) than in the aqueous solutions (20mM). When the data of two age groups were combined for analyses, significant differences in

Table 14: Geometric means of pleasantness estimates for different concentrations of sodium chloride for aqueous and food systems

NaCl (mM)	Aqueous			Food		
	Young[1]	Elderly[1]	Combined groups[2]	Young[1]	Elderly[1]	Combined groups[2]
20	9.9	7.1	8.3	6.3^{***}	6.8	6.6^{**}
40	9.6	8.5	9.1	8.1^{*}	8.3	8.1
80	8.7	9.9	9.3	10.6^{**}	10.5	10.5^{**}
160	6.6	9.1	7.8	10.3^{***}	9.8	10.0^{**}
320	3.6	5.2	4.4	7.3^{**}	6.3	6.8^{**}
640	2.3	2.8	2.5	3.5	3.3	3.4

[1] n=30

[2] n=60

*,**,*** significant at $p < 0.05, 0.01, 0.001$, respectively, between systems within the same age group pleasantness estimates between the NaCl aqueous solutions and food system were observed. At the lowest NaCl concentrations (20mM), the subjects judged the aqueous solutions to be more pleasant than the food system, while at higher NaCl concentrations (80mM or above) subjects found the food system more pleasant than the comparable aqueous solutions. In the elderly group the hedonic functions of saltiness for both aqueous and food systems were parabolic (Figure 4). However, in the young group the hedonic function for the NaCl aqueous solutions showed a decreasing monotonic trend with increasing concentration, while a parabolic function was obtained in the food system as the NaCl concentration increased.

For saltiness log pleasantness estimates no significant main effect for medium and no significant medium x concentration effect were observed in the elderly group. However, for saltiness log pleasantness estimates in the young group a significant main effect for medium ($p<0.05$) and a significant medium x concentration interaction ($p<0.001$) were found.

2.3 Demographic Effects

For each age group, the slopes of the taste intensity functions for sourness and saltiness in aqueous and food systems were examined for the effects of smoking, alcohol consumption, denture wearing, salivary pH and level of education. Of the total 30 elderly subjects only 2 were smokers, therefore, the effect of smoking on taste sensitivity was not studied in this age group. The elderly who consumed alcohol had a significantly lower slope ($p<0.05$) for saltiness in aqueous solutions than non-drinkers. However, alcohol consumption by the elderly did not affect the slopes of the taste intensity functions for saltiness in the food system as well as sourness in both the aqueous and food systems. No significant effects due to denture wearing, salivary pH or to the level of education were observed on the slopes of any of the four taste functions of the elderly subjects. For the young group, none of the demographic factors tested had any significant effect on the slopes of the taste functions studied.

3. Dietary Intake

3.1 Dietary Intake Data

Table 15 tabulates dietary energy intakes and calculated energy needs of the two groups. The mean energy intake of the elderly group was 1560 kilocalories, significantly less ($p<0.001$) than that of the young group (1893 kilocalories). Mean kilocalories per kilogram body weight were 23 for the elderly and 32 for the young. These values are the same as the recommended average energy requirements specified in the Recommended Nutrient Intakes for Canadians (1983). For the elderly group the mean energy intake was 125 percent of the mean theoretical basal requirememnt versus 135 percent for the young group (calculated for each subject using the Benedict-Harris equation).

The proportions of energy derived from protein, fat, carbohydrate and alcohol were similar for the elderly and the young as shown in Table 16. For the elderly the average proportion of energy from protein was 15 percent; fat 36 percent and carbohydrate 48 percent. For the young the average proportion of energy from protein was 15 percent; fat 33 percent and carbohydrate 51 percent. Alcohol contributed 0.2 and 0.3 percent of kilocalories for the elderly and the young, respectively.

Mean daily nutrient intakes are tabulated in Table 17. The intakes of the following nutrients were significantly

Table 15: Dietary energy intakes and basal energy requirements of the young and elderly groups

	Young[1]	Elderly[1]
Mean Energy Intake		
kcal/day	1893	1560***
kcal/kg	32.5	22.6
Calculated BER[2]		
kcal/day	1401	1264***
Energy Intake		
% of BER	135	125

[1] n=30

[2] Basal Energy Requirement

*** significant at $p < 0.001$

Table 16: Dietary sources of food energy as a percentage of energy intake for the young and elderly groups

Nutrient	Young[1]	Elderly[1]
	% of Kcal	% of Kcal
Protein	15.0 ± 0.4[2]	15.4 ± 0.6
Fat	33.5 ± 1.0	36.2 ± 1.3
Carbohydrate	50.9 ± 1.2	48.2 ± 1.1
Alcohol	0.3 ± 0.3	0.2 ± 0.2

[1] n=30

[2] mean ± standard error of the mean

Table 17: Mean daily nutrient intake (diet only) for the young and elderly groups

Nutrient	Young[1]	Elderly[1]
Energy (kcal)	1893 ± 67[2]	1560 ± 66***
Protein (g)	72.0 ± 3.3	59.8 ± 2.3**
Fat		
Total (g)	71.3 ± 3.4	64.6 ± 3.8
Cholesterol (mg)	303 ± 23	295 ± 22
Carbohydrate		
Total (g)	244 ± 10	194 ± 10***
Dietary Fiber(g)	16.7 ± 1.2	18.4 ± 1.6
Sugar (g)	115 ± 6	91 ± 6**
Starch (g)	105 ± 6	82 ± 4***
Thiamin (mg)	1.36 ± 0.07	1.30 ± 0.07
Riboflavin (mg)	1.75 ± 0.10	1.50 ± 0.08*
Preformed Niacin (mg)	16.7 ± 0.9	14.8 ± 0.8
Vitamin B6 (mg)	1.5 ± 0.1	1.3 ± 0.1
Vitamin B12 (mcg)	4.7 ± 1.0	3.8 ± 0.7
Total Folacin (mcg)	200 ± 13	178 ± 14
Ascorbic Acid (mg)	147 ± 15	123 ± 12
Vitamin A (RE)	1247 ± 204	1148 ± 161
Vitamin A (IU)	6982 ± 843	6283 ± 690
Vitamin D (IU)	189 ± 18	186 ± 16
Calcium (mg)	1003 ± 66	758 ± 45**
Phosphorus (mg)	1382 ± 68	1142 ± 60**
Iron (mg)	13.2 ± 0.5	12.5 ± 0.6
Sodium (mg)	2635 ± 143	2240 ± 111*
Potassium (mg)	2900 ± 122	2568 ± 151
Zinc (mg)	9.3 ± 0.5	7.8 ± 0.4*

[1] n=30

[2] mean + standard error of the mean

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively

lower for the elderly group than for the young group: energy ($p<0.001$); protein ($p<0.01$); total carbohydrate ($p<0.001$); sugar ($p<0.01$); starch ($p<0.001$); riboflavin ($p<0.05$); calcium ($p<0.01$); phosphorus ($p<0.01$); sodium ($p<0.05$) and zinc ($p<0.05$). For the elderly, mean intakes of calcium (758 mg) and zinc (7.8) were below the recommended levels of 800 mg and 8 mg, respectively. In addition the mean intake of folacin (178 mcg) for the elderly was below the recommended level of 190 mg per day. For the young, the mean intake of iron was 13.2 mg, just below the recommended level of 14 mg per day.

The use of vitamin/mineral supplements increased mean daily nutrient intakes as shown in Table 18. For the elderly the intakes of calcium, zinc and folacin were increased to the following levels: calcium, 825 mg; zinc, 10.8 mg; folacin, 214 mg. For the young the mean daily intake of iron from food plus supplement was 14.2 mg. Thus the use of vitamin/mineral supplements increased the mean daily intakes of all these nutrients to levels above recommendations. Only supplements that had been consumed regularly for more than six months were considered in the calculation of mean daily nutrient intakes.

The average intakes of thiamin, riboflavin, vitamin B_6 and ascorbic acid were dramatically affected by supplement use. In these cases total nutient intakes from food plus supplement reached high levels; for thiamin, mean

Table 18: Mean daily nutrient intake (diet plus vitamin/mineral supplements) for the young and elderly groups

Nutrient	Young[1]	Elderly[1]
Energy (kcal)	1983 ± 67[2]	1560 ± 66**
Protein (g)	72.0 ± 3.3	59.9 ± 2.3**
Fat		
Total (g)	71.3 ± 3.4	64.7 ± 3.8
Cholesterol (mg)	303 ± 23	295 ± 22
Carbohydrate		
Total (g)	244 ± 10	194 ± 10**
Dietary Fiber (g)	16.7 ± 1.2	18.4 ± 1.6
Sugar (g)	115 ± 6	91 ± 6**
Starch (g)	105 ± 6	82 ± 4**
Thiamin (mg)	4.28 ± 1.76	5.08 ± 1.91
Riboflavin (mg)	4.46 ± 1.73	5.06 ± 1.88
Preformed Niacin(mg)	26.7 ± 4.1	27.2 ± 5.1
Vitamin B6 (mg)	11.8 ± 6.1	4.1 ± 1.7
Vitamin B12 (mcg)	8.4 ± 2.1	7.1 ± 2.0
Total Folacin (mcg)	436 ± 171	214 ± 24
Ascorbic Acid (mg)	242 ± 39	242 ± 45
Vitamin A (RE)	1576 ± 252	1542 ± 218
Vitamin A (IU)	8079 ± 998	7596 ± 876
Vitamin D (IU)	274 ± 36	253 ± 36
Calcium (mg)	1019 ± 68	825 ± 49*
Phosphorus (mg)	1392 ± 70	1150 ± 63*
Iron (mg)	14.2 ± 0.8	13.6 ± 0.9
Sodium (mg)	2635 ± 143	2240 ± 111*
Potassium (mg)	2092 ± 122	2568 ± 151
Zinc (mg)	10.5 ± 0.9	10.8 ± 1.9

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[1] n=30

[2] mean ± standard error of the mean

*,** significant at $p < 0.05$, 0.01, respectively

intakes were 635 percent and 535 percent of the Recommended Nutrient Intake (RNI) for the elderly and young respectively; for riboflavin, 446% abd 506% of RNI; for vitamin B_6, 661% and 1903% of RNI and for ascorbic acid 538% and 538% of RNI.

Averages tend to obscure the range in individual nutrient intakes. Table 19 shows a prediction of the risk of inadequate intake. A computer program, "Probability Assessment of Nutrient Intake" (by Dr. G.H. Beaton), was used to calculate a probability estimate of true deficiencies for several nutrients. For the elderly the nutrients with the greatest risk of inadequacy were folacin (39%), calcium (31%), zinc (23%), vitamin A (12%), vitamin D (11%); for the young, folacin (16%), vitamin A (11%), zinc (11%) and iron (9%). The consumption of vitamin/mineral supplements did not have a significant impact on mean percent risk estimates for either group. However, the percent risk estimates for zinc became significantly greater for the elderly compared to the young when intake from supplement was added ($p<0.05$). For folacin and calcium the percent risk estimates were significantly greater for the elderly than the young (diet only and diet plus supplement). For iron, the percent risk estimate was significantly less for the elderly than the young (diet only and diet plus supplement). The young users of vitamin/mineral supplements (n=13) had a significant lower risk of folacin deficiency than the non-users (n=17).

Table 19: Mean percent risk[1] that observed intake is below requirement

Nutrient	Young[2]		Elderly[2]	
	diet only	diet plus Supplements	diet only	diet plus Supplements
	(%)	(%)	(%)	(%)
Protein	0.2 ± 0.2[3]	0.2 ± 0.2	7.0 ± 3.8	7.0 ± 3.8
Thiamin	0.1 ± 0.1	0.1 ± 0.1	2.9 ± 1.8	1.2 ± 1.0
Riboflavin	0.2 ± 0.2	0.2 ± 0.2	4.1 ± 2.9	1.8 ± 1.8
Vitamin B_6	1.4 ± 0.7	1.1 ± 0.7	0.2 ± 0.2	0.0 ± 0.0
Vitamin B_{12}	2.3 ± 1.8	1.7 ± 1.7	3.7 ± 3.3	3.4 ± 3.3
Total Folacin	16.1 ± 5.2	15.0 ± 5.3	39.0 ± 7.5*	34.7 ± 7.4*
Ascorbic Acid	1.8 ± 1.5	1.8 ± 1.5	5.9 ± 4.0	3.5 ± 3.3
Vitamin A	10.9 ± 4.9	9.2 ± 4.8	11.6 ± 5.0	11.2 ± 5.0
Vitamin D	9.6 ± 5.0	8.8 ± 5.0	11.2 ± 5.2	8.2 ± 4.4
Calcium	6.1 ± 3.5	4.9 ± 2.8	31.1 ± 7.2**	23.0 ± 6.6*
Iron	8.7 ± 1.3	7.7 ± 1.0	0.2 ± 0.1***	0.2 ± 0.1***
Zinc	10.6 ± 3.6	7.6 ± 2.3	23.3 ± 6.4	23.2 ± 6.4*

[1] microcomputer software package "Probability Assessement of Nutrient Intake by GH Beaton".

[2] n=30

[3] mean ± standard error of the mean

*,**,*** significant $p < 0.05$, 0.01, 0.001, respectively, between age groups within either diet only or diet plus supplements

Table 20 presents mean nutrient intake per 1000 kilocalories (nutrient densities). Densities for most nutrients exceeded those calculated from recommended intakes. The data collected show that the density of the following nutrients was significantly greater for the elderly than for the young: dietary fiber ($p<0.05$), thiamin ($p<0.05$) and iron ($p<0.01$). For iron, the figures were 8.1 mg/1000 kilocalories for the elderly and 7.1 mg/1000 kilocalories for the young. Iron density for the young was less than that calculated from Recommended Nutrient Intakes (RNI). For the elderly, folacin, calcium and zinc densities were just over those from RNI. The nutrient density of zinc was the same for both groups, a level of 5 mg/1000 kcal.

Food intakes were assessed in terms of food groups. Average quantities consumed in each group appear in Table 21. The food intakes are similar to reported values for the general population in Canada (Nutrition Canada, 1976). The young group consumed more dairy products and less meat than the average Canadian female of that age. Both the elderly and the young consumed more fruits than their average Canadian counterparts. The mean daily intake of cereal products was significantly lower for the elderly than for the young ($p<0.05$), while that of fats was significantly greater for the elderly than for the young($p<0.01$).

Table 20: Mean daily nutrient intake expressed as nutrient density (per 1000 kcal)

Nutrient	Young[1]	Elderly[1]
Energy (kcal)	1000 ± 0.0[2]	1000 ± 0.0
Protein (g)	38.0 ± 1.0	39.3 ± 1.5
Fat		
Total (g)	37.7 ± 1.0	41.1 ± 1.4
Cholesterol (mg)	160 ± 10	191 ± 12
Carbohydrate		
Total (g)	129 ± 3	124 ± 3
Dietary Fiber (g)	9.0 ± 0.6	11.4 ± 0.7*
Sugar (g)	61 ± 3	57 ± 2
Starch (g)	56 ± 2	53 ± 2
Thiamin (mg)	0.72 ± 0.03	0.84 ± 0.04*
Riboflavin (mg)	0.93 ± 0.04	0.97 ± 0.04
Vitamin B6 (mg)	0.8 ± 0.0	0.8 ± 0.0
Vitamin B12 (mcg)	2.6 ± 0.6	2.4 ± 0.3
Total Folacin (mcg)	106 ± 5	112 ± 6
Ascorbic Acid (mg)	77 ± 7	78 ± 6
Vitamin A (RE)	695 ± 125	712 ± 74
Vitamin A (IU)	3898 ± 539	3944 ± 318
Vitamin D (IU)	101 ± 9	123 ± 10
Calcium (mg)	525 ± 25	490 ± 24
Phosphorus (mg)	727 ± 20	738 ± 30
Iron (mg)	7.1 ± 0.2	8.1 ± 0.3**
Sodium (mg)	1386 ± 50	1456 ± 61
Potassium (mg)	1544 ± 45	1653 ± 72
Zinc (mg)	4.9 ± 0.2	5.1 ± 0.2

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[1] n=30

[2] mean + standard error of the mean

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively

Table 21: Mean daily intake of food groups

Food Group	Young[2]	Elderly[2]	Nutrition Canada[1] Young[3]	Nutrition Canada[1] Elderly[4]
	(g)	(g)	(g)	(g)
Dairy Products	381 ± 36.0[5]	299 ± 28.8	289	255
Meat, Poultry, Fish, Eggs	103 ± 8.7	105 ± 7.6	160	102
Cereal Products	259 ± 18.4	193 ± 16.8*	211	209
Fruit and Fruit Products	363 ± 29.1	283 ± 27.8	204	208
Vegetables	221 ± 17.5	202 ± 22.5	233	183
Fats	20 ± 1.8	31 ± 3.1**	22	16
Nuts and Dried Legumes	8 ± 2.2	3 ± 1.5	8	5
Foods Primarily Sugar	24 ± 3.1	23 ± 3.5	44	40
Miscellaneous[6]	81 ± 13.0	55 ± 10.2	106	82
All Foods (total)	1460	1194	1277	1100

[1] Food Consumption Patterns Report. Nutrition Canada.

[2] n=30

[3] National group: females from 20 to 39 years

[4] : females over 65 years old

[5] mean ± standard error of the mean

[6] include mixtures of food groups, soups, condiments and items not classified elsewhere

*,** significant at $p < 0.05$, 0.01, respectively

3.2 Demographic Effects

Relationships between mean nutrient intakes and several socioeconomic factors were examined. For the elderly, the level of education had a significant effect on the percent risk estimate of iron deficiency; as educational attainment increased from elementary school to post-secondary school the risk of iron deficiency decreased significantly ($p<0.05$) (data not presented in tabular form). Also for the elderly, economic status had a significant effect on zinc intake; individuals with incomes of $14,999 annually or less had a significantly higher risk of zinc deficiency than those whose incomes were over $15,000 annually. For both the young and the elderly, individuals eating alone had significantly higher percent risk estimates for vitamin D deficiency than others.

4. Relationships between Taste Perception and Dietary Intake

4.1 Scatterplots Showing Distribution of Percent Risk of Nutrient Deficiency vs Slope of Taste Function

Quantitative assessments of taste perception allowed comparison of the young and elderly groups. For each individual, the slope of taste intensity for sourness and saltiness in aqueous and food systems was calculated. The percent risk of nutrient deficiency was used to examine relationships between dietary intake and taste intensity parameters. For each nutrient assessed the data were plotted using the scatterplot technique with slope of taste intensity on the Y-axis and percent risk of nutrient deficiency on the X-axis. Figures 5 and 6 present the scatterplots of slopes of sour and salt taste intensity versus percent risk of vitamin A deficiency. Scatterplots for the following nutrients appear in Appendix 13: zinc, folacin and calcium. The scatterplots portray smoothed curves for the midmean, lower semi-midmean and upper semi-midmean (Cleveland and Kleiner, 1975). For vitamin A, the scatterplots for the elderly show a tendency for risk of nutrient deficiency to increase with the slope of the taste intensity function.

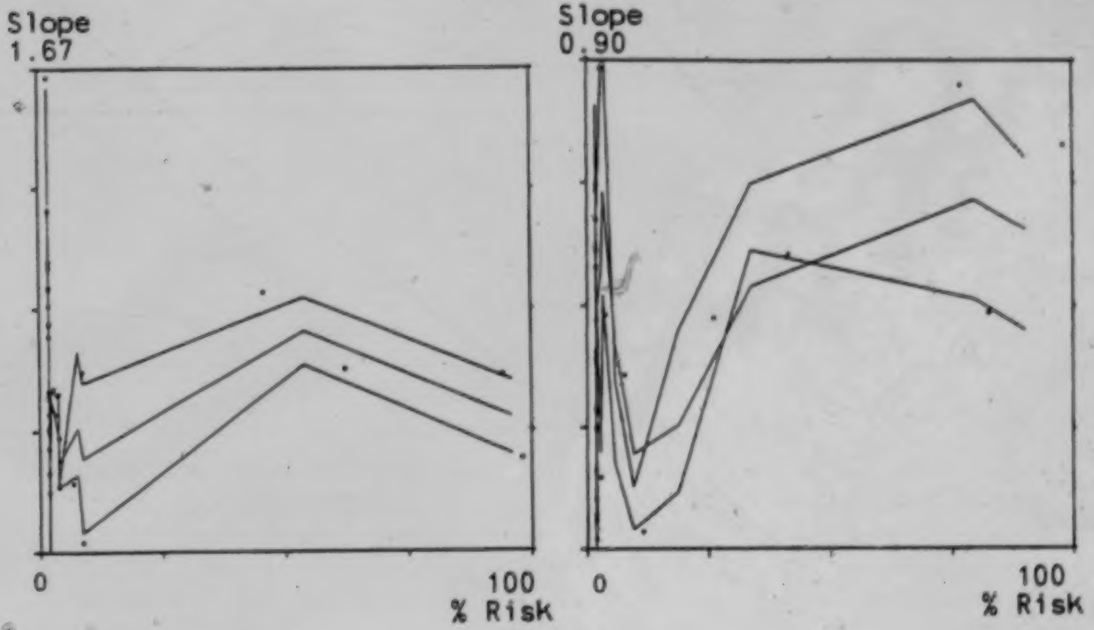
4.2 Taste Perception Data as Related to Dietary Intake

Presented in Table 22 are Pearson correlation

Figure 5: Scatterplot of slope of taste intensity vs percent risk of vitamin A deficiency: Sourness

Young Elderly

Aqueous



Food

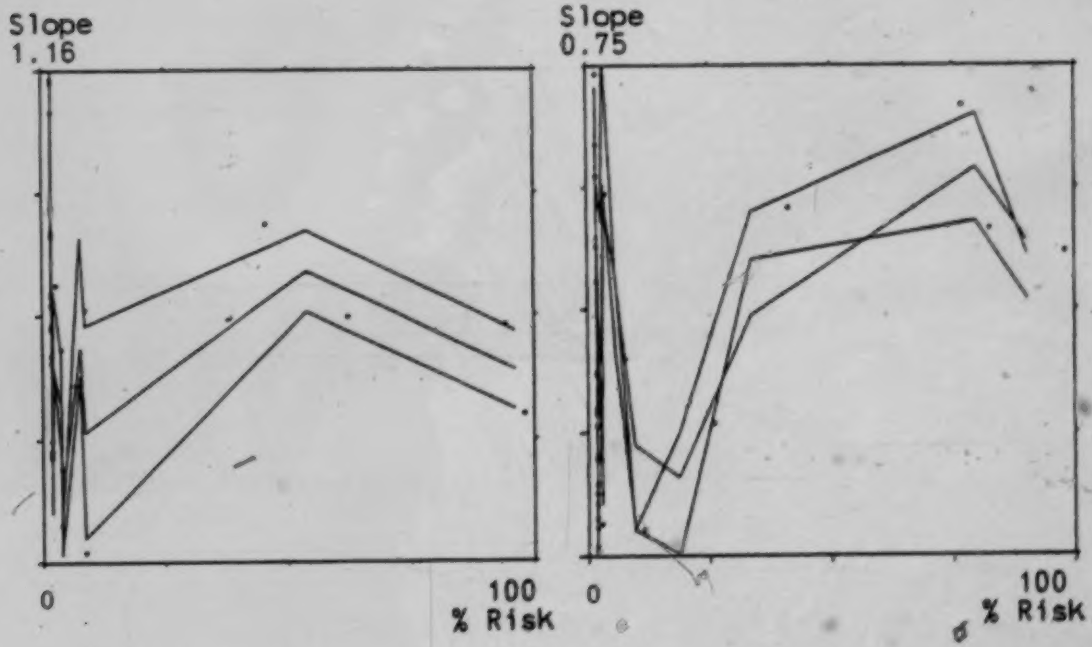
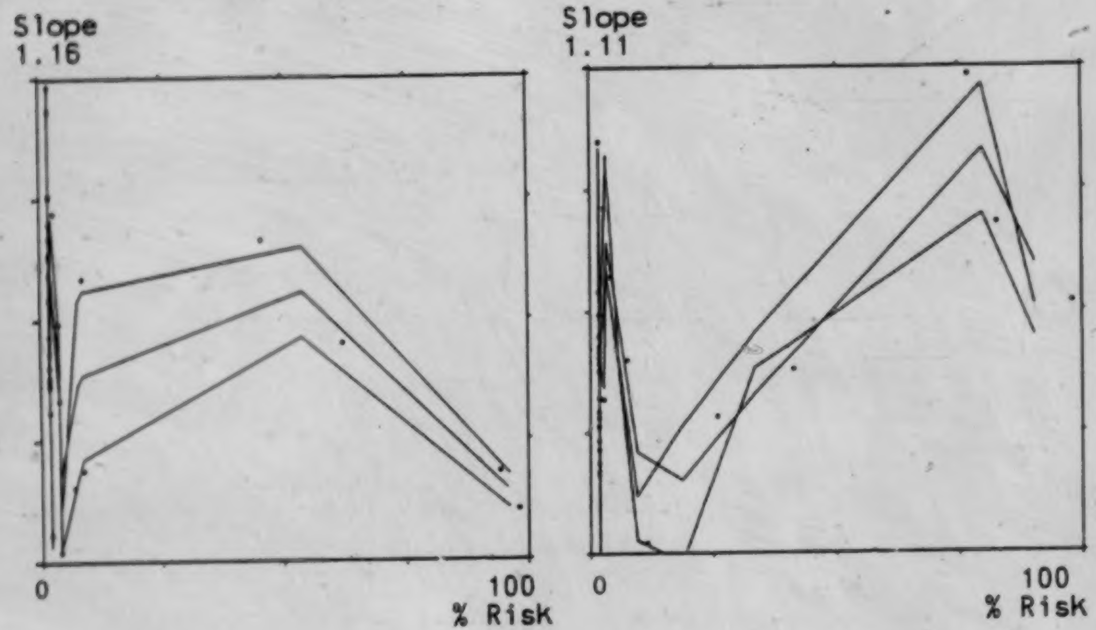


Figure 6: Scatterplot of slope of taste intensity vs percent risk of vitamin A deficiency: Saltiness

Young Elderly

Aqueous



Food

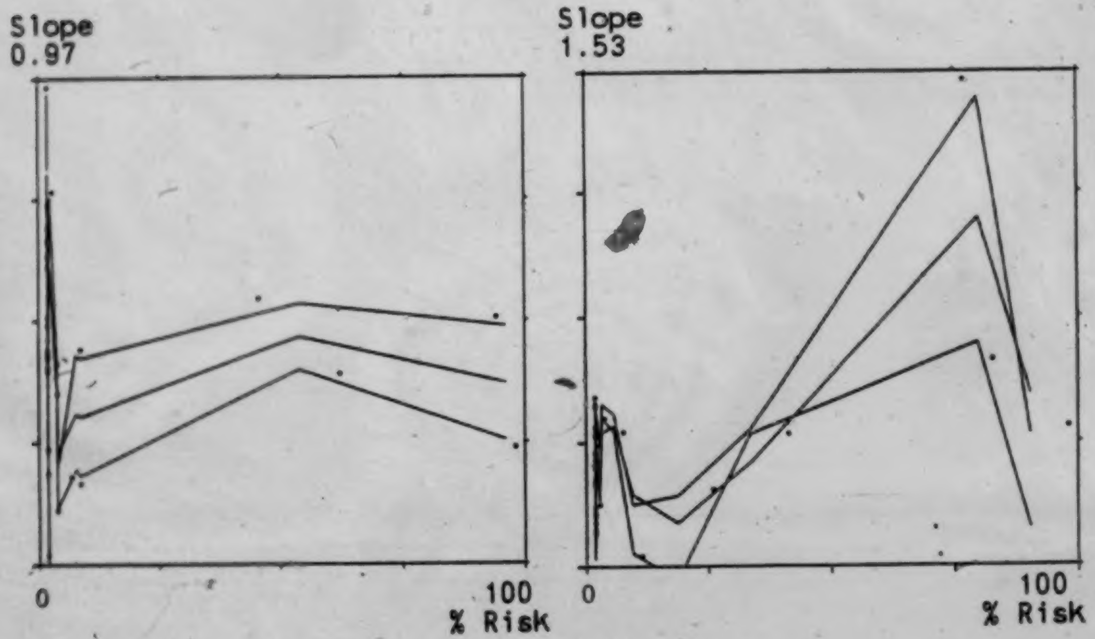


Table 22: Pearson correlation coefficients: slope of taste intensity vs percent risk of nutrient deficiency (diet only)

Nutrient	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
	Young[1]	Elderly[1]	Young[1]	Elderly[1]	Young[1]	Elderly[1]	Young[1]	Elderly[1]
Protein	-.11 (.57)[2]	-.05 (.80)	-.21 (.26)	.05 (.78)	-.06 (.74)	.05 (.79)	0.02 (.91)	.17 (.36)
Thiamin	-.11 (.57)	-.01 (.95)	-.15 (.42)	-.15 (.42)	-.08 (.69)	.11 (.56)	.11 (.55)	.13 (.51)
Riboflavin	-.17 (.37)	.07 (.73)	-.14 (.45)	.07 (.72)	-.29 (.12)	.04 (.84)	-.19 (.32)	.13 (.48)
Folacin	.04 (.82)	.12 (.53)	.07 (.70)	.22 (.23)	.28 (.13)	.16 (.41)	.09 (.65)	.21 (.28)
Vit.B12	-.02 (.93)	.27 (.15)	.02 (.91)	.14 (.45)	-.15 (.43)	.10 (.60)	-.14 (.45)	.06 (.74)
Vit.B6	-.13 (.50)	-.17 (.37)	-.07 (.71)	-.08 (.66)	.07 (.71)	-.12 (.53)	-.01 (.98)	.06 (.76)
Vit.C	-.08 (.69)	-.07 (.71)	-.10 (.59)	.09 (.64)	.04 (.84)	.13 (.50)	.02 (.92)	.22 (.24)
Vit.A	-.10 (.61)	.42 (.02)*	-.07 (.70)	.39 (.03)*	-.33 (.07)	.43 (.02)*	-.12 (.52)	.57 (.00)***
Vit.D	-.04 (.82)	-.13 (.48)	-.16 (.40)	-.05 (.80)	-.06 (.77)	-.08 (.68)	-.08 (.67)	.04 (.85)
Calcium	-.12 (.52)	.20 (.29)	-.17 (.36)	.36 (.05)*	-.09 (.64)	.37 (.04)*	-.05 (.81)	.49 (.01)**
Iron	-.19 (.30)	.08 (.68)	-.02 (.91)	-.04 (.81)	.08 (.68)	.11 (.55)	.09 (.64)	.17 (.38)
Zinc	-.06 (.76)	.04 (.84)	.03 (.86)	.15 (.44)	.23 (.23)	.11 (.56)	.29 (.12)	.11 (.57)

---

[1] n=30; [2] probability level of significance

*,**,*** significantly correlated at $p < 0.05, 0.01, 0.001$, respectively

coefficients comparing slopes for sourness and saltiness in aqueous and food systems with mean percent risk that the observed intake of nutrients was below requirement. For the elderly, significant positive correlations were noted between the following: % risk of vitamin A deficiency vs. slopes for sourness in both the aqueous ($p<0.05$) and food ($p<0.05$) systems; % risk of vitamin A deficiency vs. slopes for saltiness in both the aqueous ($p<0.05$) and food ($p<0.001$) systems; % risk of calcium deficiency vs. slope for sourness in the food system ($p<0.05$); % risk of calcium deficiency vs. slopes for saltiness in both aqueous ($p<0.05$) and food ($p<0.01$) systems. For the young group, there were no significant correlations between the slopes of taste intensity and percent risk of nutrient deficiencies.

Presented in Table 23 are Pearson correlation coefficients comparing slopes for sourness and saltiness in aqueous and food systems with mean percent risk of nutrient deficiency from diet plus supplement. In this case significant positive correlations were again obtained for the elderly between the following: % risk of vitamin A deficiency vs. slopes for sourness in both aqueous ($p<0.05$) and food ($p<0.05$) systems, and slopes for saltiness in both aqueous ($p<0.05$) and food ($p<0.001$) systems. A negative correlation was also found for the young between % risk of vitamin A deficiency and the slope for saltiness in the aqueous system.

Table 23: Pearson correlation coefficients: slope of taste intensity vs percent risk of nutrient deficiency (diet plus vitamin/mineral supplements)

Nutrient	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
	Young^1	Elderly^1	Young^1	Elderly^1	Young^1	Elderly^1	Young^1	Elderly^1
Protein	-.11 (.57)^2	-.05 (.80)	-.21 (.26)	.05 (.78)	-.06 (.74)	.05 (.79)	-.02 (.91)	.17 (.36)
Thiamin	-.10 (.59)	.02 (.92)	-.19 (.31)	.03 (.87)	-.16 (.39)	.02 (.93)	.00 (1.0)	.06 (.76)
Riboflavin	-.17 (.37)	.28 (.14)	-.14 (.45)	.14 (.46)	-.29 (.12)	.10 (.60)	-.19 (.32)	.06 (.77)
Folacin	.04 (.84)	.16 (.41)	.06 (.74)	.30 (.11)	.26 (.16)	.16 (.41)	.08 (.66)	.21 (.28)
Vit.B12	-.00 (.98)	.27 (.15)	-.00 (.99)	.14 (.47)	-.23 (.23)	.09 (.63)	.05 (.80)	.05 (.79)
Vit.B6	-.11 (.55)	.03 (.87)	-.09 (.64)	-.09 (.64)	.03 (.89)	-.11 (.55)	-.01 (.96)	-.08 (.66)
Vit.C	-.08 (.69)	-.11 (.55)	-.10 (.59)	-.02 (.93)	.04 (.84)	-.02 (.90)	.02 (.92)	.12 (.51)
Vit.A	-.15 (.44)	.43 (.02)*	-.12 (.51)	.40 (.03)*	-.38 (.04)*	.45 (.01)*	-.15 (.43)	.58 (.00)***
Vit.D	-.06 (.77)	.00 (1.0)	-.16 (.41)	.01 (.97)	-.09 (.65)	.02 (.92)	-.11 (.58)	.08 (.66)
Calcium	-.18 (.34)	.03 (.89)	-.21 (.26)	.09 (.62)	-.20 (.30)	.02 (.93)	-.12 (.52)	.06 (.76)
Iron	-.29 (.12)	.08 (.68)	-.10 (.60)	-.04 (.81)	.02 (.91)	.11 (.55)	.10 (.58)	.17 (.38)
Zinc	-.05 (.80)	.04 (.84)	.03 (.88)	.14 (.45)	.12 (.52)	.11 (.58)	.10 (.61)	.11 (.57)

^{1} n=30; ^{2} probability level of significance

*,*** significantly correlated at $p< 0.05$, 0.001, respectively

Partial correlation coefficients calculated by controlling for energy intake revealed the following positive correlations for the elderly (data not presented in tabular form): percent risk of vitamin A deficiency (diet only and diet plus vitamin/mineral supplement) vs. slopes for sourness in aqueous ($p<0.05$) and food ($p<0.05$) systems and for saltiness in aqueous ($p<0.05$) and food ($p<0.01$) systems; % risk of folacin deficiency (diet only) vs. slope for sourness in food system ($p<0.05$); % risk of calcium deficiency (diet only) vs. slope for sourness in food system ($p<0.05$) and for saltiness in food system ($p<0.05$). For the young one negative correlation achieved statistical significance: % risk of vitamin A deficiency (diet plus vitamin/mineral supplement) vs. slope for saltiness in food system ($p<0.05$).

The probability assessment of nutrient deficiency is one indicator of the quality of dietary intake; another is nutrient density. Table 24 indicates the Pearson correlation coefficients comparing suprathreshold taste intensity data and nutrient densities for the elderly and the young. Significant negative correlations were noted between the following: protein density for the young vs. slope for saltiness in the food system ($p<0.05$); zinc density for the young vs. slope for sourness in the food system ($p<0.01$) and vs. slopes for saltiness in aqueous ($p<0.01$) and food ($p<0.01$) systems. In addition for the

Table 24: Pearson correlation coefficients: slope of taste intensity vs nutrient density (diet only)

Nutrient	Sourness				Saltiness			
	Aqueous		Food		Aqueous		Food	
	Young[1]	Elderly[1]	Young[1]	Elderly[1]	Young[1]	Elderly[1]	Young[1]	Elderly[1]
Protein	-.17	-.00	-.34	-.09	-.32	.20	-.41	.08
	(.38)	(.98)	(.06)	(.63)	(.08)	(.28)	(.03)*	(.67)
Fat	-.14	-.00	.05	.01	-.10	.05	-.07	.24
	(.46)	(1.0)	(.81)	(.97)	(.61)	(.80)	(.71)	(.20)
Carbohydrate	.13	-.02	.07	.05	.23	-.15	.21	-.32
	(.49)	(.93)	(.72)	(.79)	(.22)	(.42)	(.26)	(.08)
Thiamin	.06	-.18	-.14	-.12	-.04	.07	-.04	.05
	(.75)	(.35)	(.46)	(.51)	(.85)	(.71)	(.85)	(.78)
Riboflavin	.13	-.01	.03	-.26	.17	.04	.11	-.13
	(.49)	(.96)	(.89)	(.16)	(.36)	(.82)	(.55)	(.50)
Vit.B6	.24	-.10	-.10	-.13	-.12	.07	.10	-.07
	(.20)	(.59)	(.59)	(.49)	(.52)	(.71)	(.60)	(.72)
Vit.B12	.10	-.10	-.01	-.18	.19	-.17	.18	-.09
	(.61)	(.59)	(.97)	(.34)	(.32)	(.37)	(.33)	(.63)
Folacin	-.02	-.21	-.20	-.10	-.29	-.03	-.11	-.06
	(.93)	(.27)	(.28)	(.59)	(.12)	(.90)	(.58)	(.77)
Ascorbic Acid	.01	-.24	-.14	-.15	-.28	-.08	-.06	-.05
	(.97)	(.20)	(.47)	(.43)	(.14)	(.66)	(.73)	(.81)
Vit.A	.15	-.11	-.01	-.22	.26	-.16	.29	-.19
	(.43)	(.57)	(1.0)	(.24)	(.17)	(.41)	(.12)	(.31)
Vit.D	-.25	.15	-.08	-.13	-.15	.39	-.24	.17
	(.18)	(.42)	(.66)	(.50)	(.43)	(.03)*	(.21)	(.36)
Calcium	.11	.00	.22	-.34	.21	.06	.04	-.15
	(.57)	(.98)	(.25)	(.07)	(.26)	(.77)	(.82)	(.43)
Phosphorus	.38	.03	.19	-.17	.16	.06	.16	-.10
	(.04)*	(.89)	(.31)	(.36)	(.41)	(.76)	(.38)	(.62)
Iron	.18	.06	-.17	.06	.04	.08	.02	.11
	(.34)	(.76)	(.37)	(.74)	(.85)	(.68)	(.92)	(.57)
Sodium	-.06	.17	-.06	.13	.04	.16	-.09	.21
	(.75)	(.38)	(.77)	(.49)	(.85)	(.40)	(.64)	(.27)
Potassium	.05	-.08	-.13	-.21	-.21	.04	-.14	-.08
	(.78)	(.67)	(.50)	(.27)	(.28)	(.85)	(.46)	(.68)
Zinc	-.26	.11	-.49	.01	-.46	.20	-.49	.17
	(.16)	(.56)	(.01)**	(.96)	(.01)**	(.30)	(.01)**	(.36)

[1] n=30; *,** significant correlated at $p < 0.05$, 0.01, respectively

elderly a significant positive correlation was noted between vitamin D density and slope for saltiness in the food system ($p<0.05$). For the young a significant positive correlation was noted between phosphorus density and slope for sourness in the aqueous system ($p<0.05$).

Multivariate analyses (canonical correlations) were conducted to evaluate interrelationships among individual nutrient and taste perception data. Slopes for sourness and saltiness in aqueous and food systems were compared with mean nutrient intakes (with and without supplements) as shown in Table 25. Significant correlations were noted between the following: for the elderly, sugar intake and taste parameters ($p<0.05$); and for the young, dietary fiber intake and taste parameters ($p<0.01$); iron intake and taste parameters ($p<0.05$); potassium intake and taste parameters ($p<0.05$); vitamin B_6 intake (diet only) and taste parameters ($p<0.001$) and phosphorus intake (diet plus supplement) and taste parameters ($p<0.05$).

Presented in Table 26 are canonical correlations comparing the 4 taste parameters and the probability estimates of nutrient inadequacies. The following significant correlations were noted: for the elderly, % risk of vitamin A deficiency and taste parameters ($p<0.05$); for the young, % risk of zinc deficiency (diet only) and taste parameters ($p<0.05$); % risk of vitamin B_{12} deficiency (diet only) and taste parameters ($p<0.05$) and %

Table 25: Canonical correlations: slope of taste intensity for two taste qualities and two systems vs nutrient intake (with and without vitamin/mineral supplements)

Nutrient	Young		Elderly	
	diet only[1]	diet plus supplements[1]	diet only[1]	diet plus supplements[1]
Energy (Kcal)	.50	.50	.39	.39
Protein (g)	.51	.51	.33	.33
Fat				
Total (g)	.47	.47	.24	.24
Cholesterol (mg)	.24	.24	.36	.36
Carbohydate				
Total (g)	.35	.35	.47	.47
Dietary fiber (g)	.69**	.69**	.28	.28
Sugar (g)	.40	.40	.59*	.59*
Starch (g)	.22	.22	.27	.27
Thiamin (mg)	.38	.30	.30	.33
Riboflavin (mg)	.31	.31	.39	.31
Vit.B6 (mg)	.71***	.30	.33	.29
Vit.B12 (mcg)	.25	.20	.27	.30
Total Folacin (mcg)	.50	.36	.28	.26
Ascorbic acid (mg)	.48	.29	.28	.33
Vit.A (RE)	.39	.39	.27	.15
Vit.D (IU)	.32	.32	.52	.17
Calcium (mg)	.39	.43	.49	.21
Phosphorus (mg)	.54	.57*	.38	.36
Iron (mg)	.61*	.66*	.30	.31
Sodium (mg)	.26	.26	.21	.20
Potassium (mg)	.60*	.60*	.30	.30
Zinc (mg)	.53	.49	.21	.27

[1] n=30

*,**,*** significantly correlated at $p < 0.05$, 0.01, 0.001, respectively

Table 26: Canonical correlations: slope of taste intensity for two taste qualities and two systems vs percent risk of nutrient deficiency (diet with and without vitamin/mineral supplements)

Nutrient	Young		Elderly	
	diet only[1]	diet plus supplements[1]	diet only[1]	diet plus supplements[1]
Protein	.28	.28	.26	.26
Thiamin	.46	.33	.32	.07
Riboflavin	.32	.32	.18	.32
Folacin	.41	.38	.27	.32
Vit.B12	.57*	.51	.31	.32
Vit.B6	.27	.21	.67	.27
Vit.C	.22	.22	.36	.22
Vit.A	.48	.53	.59*	.60*
Vit.D	.23	.21	.21	.12
Calcium	.21	.25	.54	.12
Iron	.48	.66*	.27	.27
Zinc	.58*	.27	.21	.20

[1] n=30

* significantly correlated at $p < 0.05$

9

risk of iron deficiency (food plus supplement) and taste parameters ($p<0.05$).

4.3 Range of Variability of Taste Intensity Data: Creation of Subgroups

Since the average slopes of taste intensity obscure the range in individual values, coefficients of variability were calculated to give an indication of person-to-person variability. For each of the taste qualities and systems the slopes for the individual subjects were ranked in decreasing order and two equal subgroups were created in each age group : subgroup I exhibited steeper ME taste intensity slopes and subgroup II had flatter ME taste intensity slopes. Table 27 shows the taste intensity slopes for subgroups I and subgroups II. Ranges in individual values for slopes of taste function are tabulated. Tables 28 and 29 show the variability in magnitude estimation intensity data for individuals; Table 28 for the sour quality and Table 29 for the salt quality. Subjects in subgroup I with steeper ME taste intensity slopes exhibited larger variability in log intensity estimates than subjects in subgroup II. In some cases there were significant differences between subgroups, indicating greater taste response variability in subgroup I than subgroup II. For both sourness and saltiness significant differences in variability between the elderly and the young groups were also observed at some concentrations (Tables 28 and 29).

Table 27: Mean slope of the sour and taste qualities for the young and elderly subgroups

Slope of taste intensity	Young		Elderly	
	Subgroup[1] I	Subgroup[1] II	Subgroup[1] I	Subgroup[1] II
Sourness:				
Aqueous	.99 (.72-1.67)[2]	.55 (.25-.71)	.64 (.45-.90)	.30 (.15-.44)
Food	.80 (.61-1.16)	.39 (.07-.59)	.50 (.30-.75)	.15 (.05-.25)
Saltiness:				
Aqueous	.89 (.71-1.16)	.52 (.28-.69)	.66 (.48-.1.11)	.34 (.09-.47)
Food	.65 (.49-.97)	.36 (.12-.48)	.57 (.42-.1.53)	.27 (.11-.39)

[1] n=15

[2] range of the slope values

Table 28: Percent coefficient of variability[1] of intensity estimates for different concentrations of citric acid for the young and elderly subgroups

Citric Acid (mM)	Young Subgroup[2] I	Young Subgroup[2] II	Elderly Subgroup[2] I	Elderly Subgroup[2] II
Aqueous Solutions:				
3	26	15	30	12
6	18	13	15	11
12	12	9	14	9
18	8	9	10	9
24	12	7	13	12
36	11	8	12	10
Apple Drink Samples:				
3	38	20	18	9
6	27	9	10	6
12	16	8	11	7
18	14	10	10	6
24	8	10	11	7
36	11	12	18	7

[1] (standard deviation/mean) x 100

[2] n=15

Table 29: Percent coefficient of variability of intensity estimates for different concentrations of sodium chloride for the young and elderly subgroups

NaCl (mM)	Young		Elderly	
	Subgroup[1] I	Subgroup[1] II	Subgroup[1] I	Subgroup[1] II
Aqueous Solutions:				
20	50	18	39	13
40	25	13	20	11
80	15	8	7	9
160	10	10	14	8
320	9	8	12	10
640	10	9	11	12
Soup Samples:				
20	21	11	58	11
40	14	7	16	13
80	14	8	10	8
160	7	11	10	6
320	10	10	10	11
640	10	11	7	9

[1] n=15

4.4 Taste Intensity Data of Subgroups as Related to Overall Index of Nutritional Risk

The elderly subjects with steeper ME taste intensity slopes tended to be at greater nutritional risk on the basis of probability estimates of true deficiencies (Table 30). An index of the overall nutritional risk was calculated as the average of the individual's percent risk of deficiency for twelve nutrients: protein, thiamin, riboflavin, folacin, vitamin B_6, vitamin B_{12}, vitamin A, vitamin D, ascorbic acid, calcium, iron and zinc. Figures 7 and 8 show these indices for the various subgroups (nutrient intake from diet only). For subgroup I of the elderly, the mean index of nutritional risk was significantly higher than for subgroup II for both food systems (sourness $p<0.05$ and saltiness $p<0.01$). That is, the elderly subjects with steeper ME taste intensity slopes had a higher incidence of nutrient deficiencies. Of the fifteen subjects in subgroup I, 12 were classified as subgroup I for both food systems. Similarly 12 of 15 subjects in the young subgroup I were classified as subgroup I for both food systems. For subgroup I of the elderly, the mean indices of nutritional risk were also significantly higher than those of subgroup I of the young group for sourness in food system and for saltiness in both aqueous and food systems.

Table 30: Overall indices of nutritional risk for the young and elderly subgroups for two taste qualities and two systems

Taste Quality	System	Young Subgroup[1] I	 Subgroup[1] II	Elderly Subgroup[1] I	 Subgroup[1] II
Sourness	Aqueous	6.6	4.7	14.0	9.4
	Food[2]	5.4	5.9	17.7†	5.7*
Saltiness	Aqueous	5.8	5.6	14.3†	9.1
	Food[3]	6.0	5.3	18.7†	4.7**

[1] n=15

[2] apple drink

[3] chicken soup

† significant at $p < 0.05$ between age groups within the same subgroup

*,** significant at $p < 0.05$, 0.01, respectively, between subgroups of the same age group

Figure 7: Overall index of nutritional risk for the young and elderly subgroups: sourness for aqueous and food systems

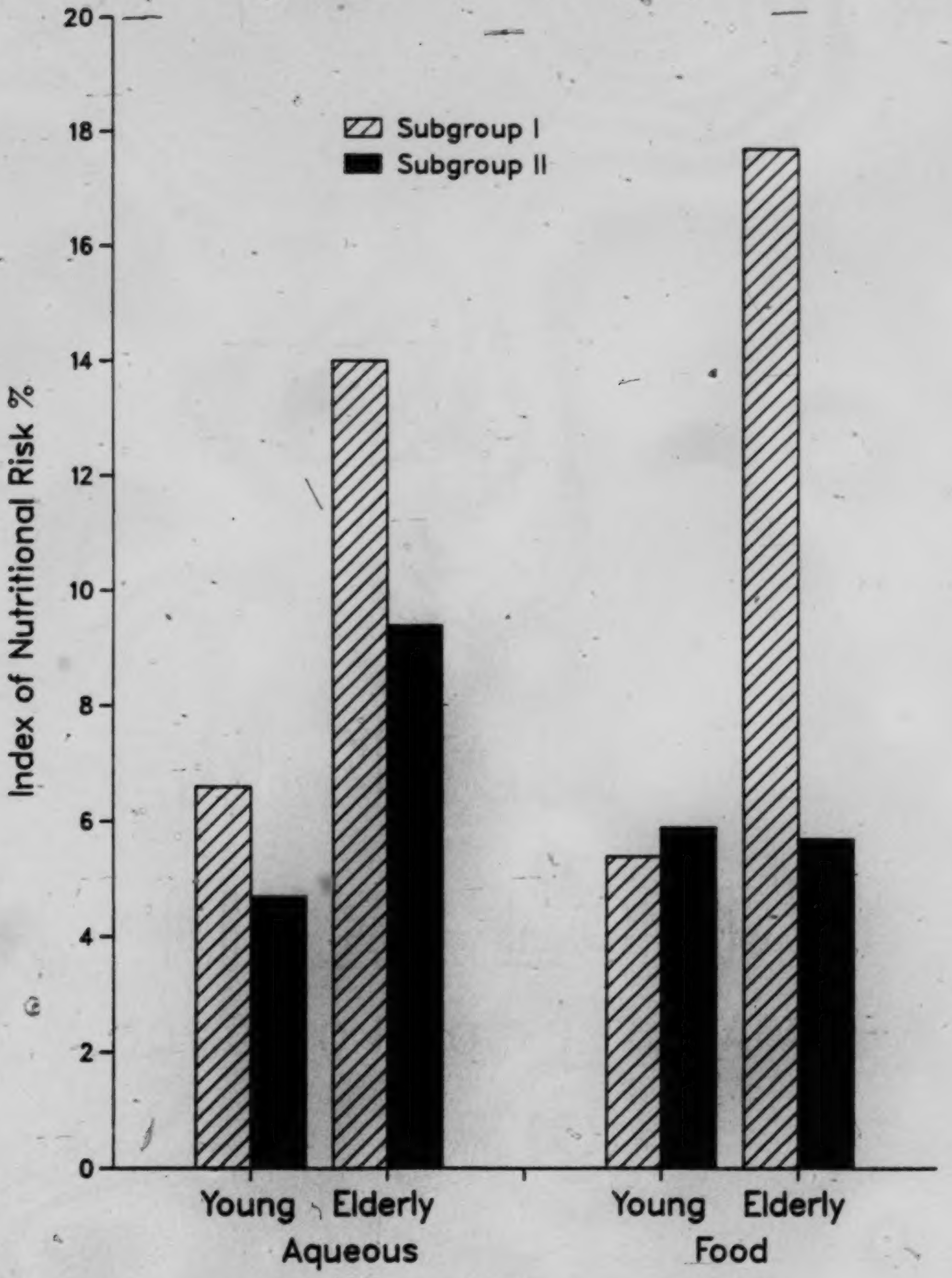
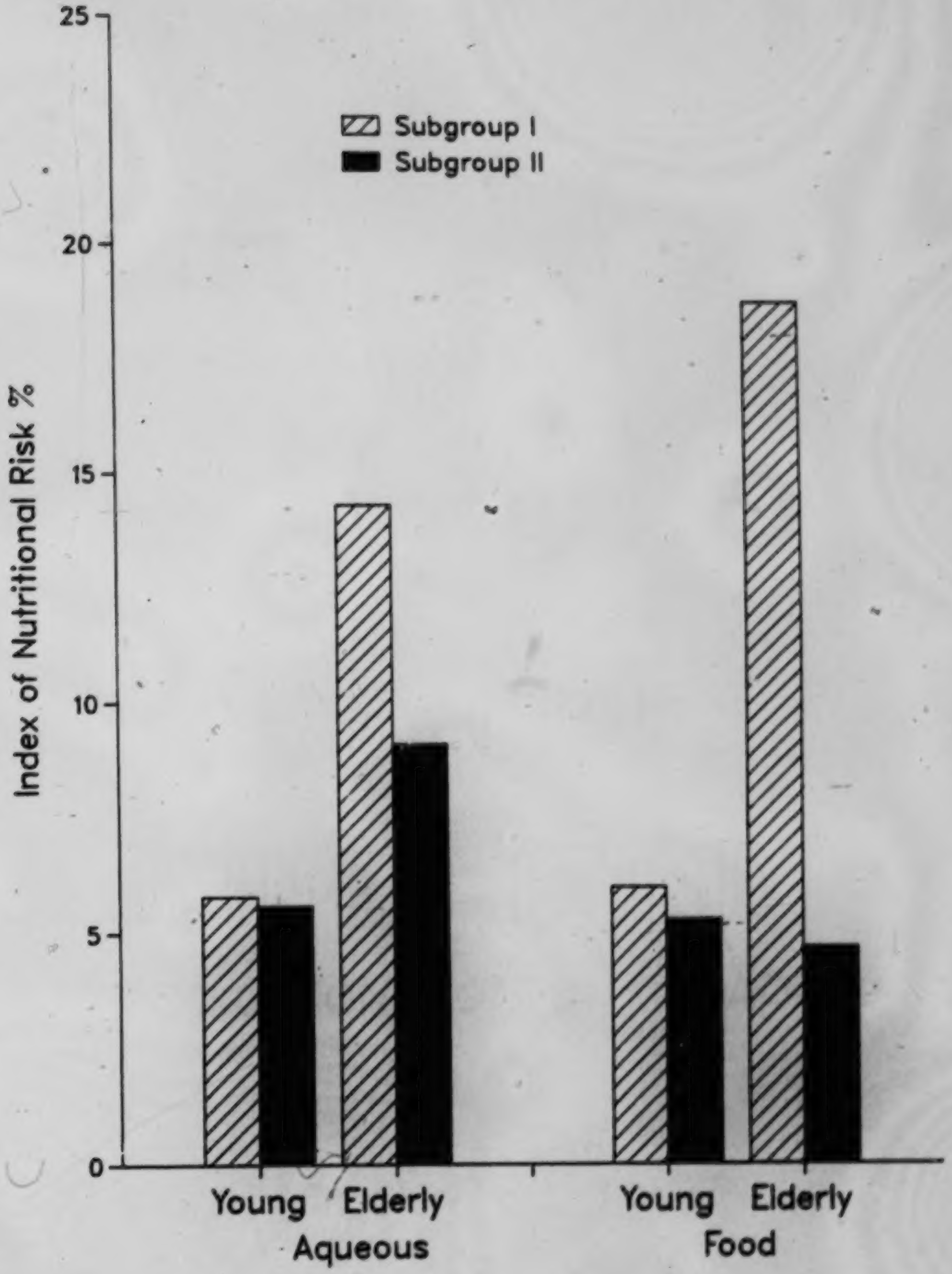


Figure 8: Overall index of nutritional risk for the young and elderly subgroups: saltiness for aqueous and food systems



4.5 Taste Pleasantness Data of Subgroups

The effect of taste stimulus intensity on perceived pleasantness was also examined. Pleasantness reponses (hedonic responses) were measured using the method of magnitude estimation. The coefficients of variability of individual hedonic responses were examined for both groups and subgroups (Table 31 for sour quality and Table 32 for salt quality). For both elderly and young subjects, the pleasantness ratings for both taste qualities of the subgroups with the steeper ME taste intensity slopes (subgroup I) exhibited more variability than ratings for subgroup II. For sourness in both systems the coefficients of variabilty of pleasantness estimates were generally smaller among the elderly than among the young subjects, but similar observations were not found for saltiness.

The patterns of pleasantness responses to taste qualities were plotted for the groups and subgroups (mean log pleasantness ratings were used - Figures 9 and 10). The patterns of pleasantness responses to aqueous citric acid solutions are shown in Figure 9. Subgroup II of both the elderly and young groups rated citric acid aqueous solutions as tasting more pleasant than subgroup I. The concentrations perceived as most pleasant were as follows: for the elderly, 6mM and 3mM for subgroups I and II respectively; for the young, 3mM for both subgroups I and

Table 31: Percent coefficient of variability of pleasantness of estimates for different concentrations of citric acid for the young and elderly subgroups

Citric Acid (mM)	Young		Elderly	
	Subgroup[1] I	Subgroup[1] II	Subgroup[1] I	Subgroup[1] II
Aqueous Solutions:				
3	28	12	28	9
6	20	12	15	7
12	24	14	14	11
18	24	15	32	13
24	45	27	47	17
36	74	46	54	25
Apple Drink Samples:				
3	36	14	20	9
6	26	7	10	8
12	12	7	12	7
18	10	10	15	6
24	18	15	25	7
36	29	28	37	12

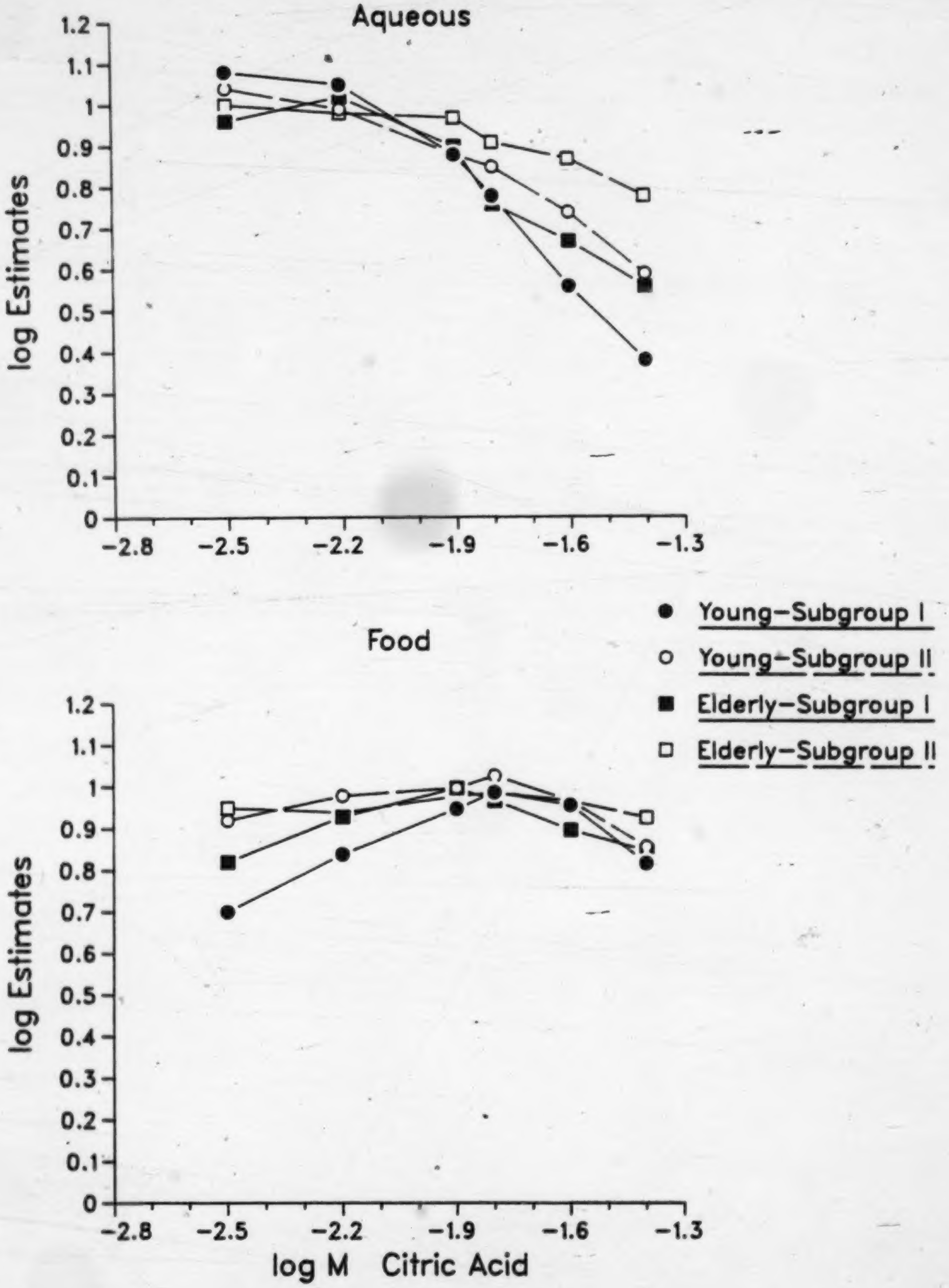
[1] n=15

Table 32: Percent coefficient of variability of pleasantness estimates for different concentrations of sodium chloride for the young and elderly subgroups

NaCl (mM)	Young Subgroup[1] I	Young Subgroup[1] II	Elderly Subgroup[1] I	Elderly Subgroup[1] II
Aqueous Solutions:				
20	23	17	29	20
40	23	13	16	12
80	18	6	7	13
160	26	20	24	15
320	129	39	66	18
640	622	50	109	45
Soup Samples:				
20	24	14	32	13
40	11	8	18	13
80	10	6	10	5
160	16	13	29	10
320	46	15	55	21
640	135	28	105	54

[1] n=15

Figure 9: Log pleasantness estimates of citric acid for the young and elderly subgroups



II. For both groups, significant differences were found between the pleasantness ratings for sourness of subgroup I and subgroup II (Table 33). For the elderly, subgroup I rated the three highest citric acid concentrations in aqueous solutions less pleasant than did subgroup II (18mM, $p<0.05$; 24mM, $p<0.05$; 36mM, $p<0.05$). For the young, subgroup I rated the two highest citric acid concentrations in aqueous solution less pleasant than did subgroups II (24mM, $p<0.05$; 36mM, $p<0.05$).

The patterns of pleasantness responses to apple drink samples of various citric acid concentrations are shown in Figure 9. Subgroup I of both groups rated the lowest CA concentration in drink as least pleasant. Citric acid concentrations had little influence on the pleasantness ratings of apple drink for the elderly. The young subgroup II rated as least pleasant apple drink at the highest citric acid concentrations. The highest pleasantness ratings were as follows: for the elderly, 12mM and 18mM for subgroups I and II, respectively; for the young 18mM for both subgroups I and II. For both groups, significant differences were found between the pleasantness ratings of subgroup I and subgroup II (Table 33). For the elderly, subgroup I rated the lowest citric acid concentration in drink as tasting less pleasant than did subgroup II (3mM, $p<0.01$). For the young, subgroup II rated the two lowest citric acid concentrations in drink as tasting more pleasant than did subgroup I (3mM, $p<0.01$; 6mM, $p<0.05$).

Table 33: Geometric means of pleasantness estimates for different concentrations of citric acid for the young and elderly subgroups

Citric Acid(mM)	Young Subgroup[1] I	Young Subgroup[1] II	Elderly Subgroup[1] I	Elderly Subgroup[1] II
Aqueous Solutions:				
3	12.0	11.0	9.1	10.0
6	11.2	9.8	10.5	9.6
12	7.6	7.6	7.9	9.3†
18	6.0	7.1	5.8	8.1*
24	3.6	5.5*	4.7	7.4*
36	2.4	3.9*	3.6	6.0*,†
Apple Drink Samples:				
3	5.0	8.3**	6.6	8.9**
6	6.9	9.6*	8.5	8.7
12	8.9	10.0	10.0	9.6
18	9.8	10.7	9.3	9.8
24	9.1	9.3	8.1	9.3
36	6.6	7.2	7.1	8.5

[1] n=15

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively, between subgroups within the same age group

† significant at $p < 0.05$ between age groups within the same subgroup

The patterns of pleasantness responses to aqueous sodium chloride solutions are shown in Figure 10. For both groups, salt solutions decreased in pleasantness as they increased in concentration. The highest salt pleasantness ratings were as follows: for the elderly, 80mM for both subgroups I and II; for the young, 20mM and 80mM for subgroups I and II, respectively. For both age groups significant differences were found between the salt pleasantness ratings of subgroup I and subgroup II (Table 34). For the elderly, subgroup I rated the two highest salt concentrations as significantly less pleasant than did subgroup II (320mM, $p<0.05$; 640mM, $p<0.05$). For the young, subgroup I rated the four highest salt concentrations as less pleasant than did subgroup II (80mM, $p<0.01$; 160mM, $p<0.01$; 320mM, $p<0.01$; 640mM, $p<0.001$).

The patterns of pleasantness responses to soup samples of various salt concentrations are shown in Figure 10. The pleasantness ratings of soup tended to show a parabolic function as salt concentration increased. The highest pleasantness ratings were as follows: for the elderly, 80mM for subgroup I and 80mM and 160mM for subgroup II; for the young, respectively, 80mM and 160mM for subgroup I and II. For both age groups, significant differences were found between the soup pleasantness ratings of subgroup I and subgroup II (Table 34). For the elderly, subgroup II rated the lowest salt concentration more pleasant than did

Figure 10: Log pleasantness estimates of sodium chloride for the young and elderly subgroups

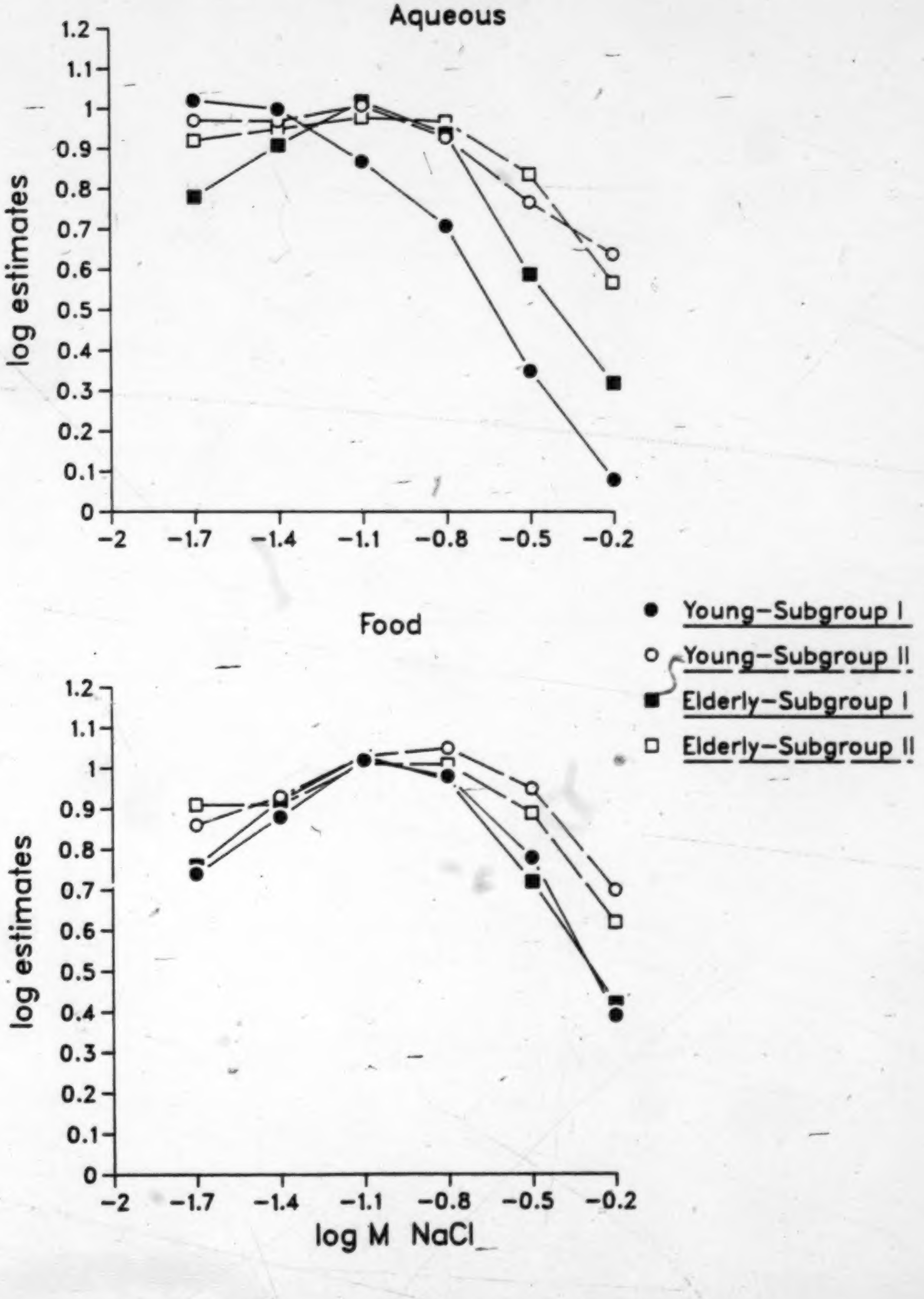


Table 34: Geometric means of pleasantness estimates for different concentrations of sodium chloride for two systems for the young and elderly subgroups

NaCl (mM)	Young Subgroup[1] I	Young Subgroup[1] II	Elderly Subgroup[1] I	Elderly Subgroup[1] II
Aqueous Solutions:				
20	10.5	9.3	6.0††	8.3
40	10.0	9.3	8.1	8.9
80	7.4	10.2**	10.5††	9.6
160	5.1	8.5**	8.7††	9.3
320	2.2	5.9**	3.9	6.9*
640	1.2	4.4***	2.1	3.7*
Soup Samples:				
20	5.5	7.2*	5.8	8~~.1*~~
40	7.6	8.5	8.3	8.1
80	10.5	10.7	10.7	10.2
160	9.6	11.2	9.3	10.2
320	6.0	8.9	5.3	7.8
640	2.5	5.1*	2.6	4.2

[1] n=15

*,**,*** significant at $p < 0.05, 0.01, 0.001$, respectively, between subgroups within the same age group

†† significant at $p < 0.01$ between age groups within the same subgroup

subgroup I (20mM, $p<0.05$). For the young, subgroup I rated the lowest and highest salt concentrations in soup less pleasant than did subgroup II (20mM, $p<0.05$; 640mM, $p<0,05$).

In general, for the aqueous systems pleasantness decreased as CA and salt concentration increased. This pattern of response across the suprathreshold range was more pronounced for subgroup I than for subgroup II. In general, for the simple food systems, the pattern of hedonic response to CA and salt concentration was parabolic (Figure 9 and 10). The intermediate stimulus concentrations were preferred. For both taste qualities in aqueous solutions and for salt in the food system, subgroup I assigned the lowest pleasantness ratings to high concentrations. Subgroup I, the subjects with the steeper ME taste intensity slopes, exhibited narrower ranges of preference and a greater dislike for concentrations higher and lower than the preferred range compared to subgroup II (for both the elderly and the young).

An index of hedonic response was determined for each subject by calculating the absolute differences between the lowest and highest pleasantness ratings for each taste quality in each system. Figures 11 and 12 show the average indices of hedonic response for sourness and saltiness, respectively, for the subgroups of the elderly and the young. A significant age effect was found for sourness for

Figure 11: Overall index of hedonic response for the young and elderly subgroups: sourness for aqueous and food systems

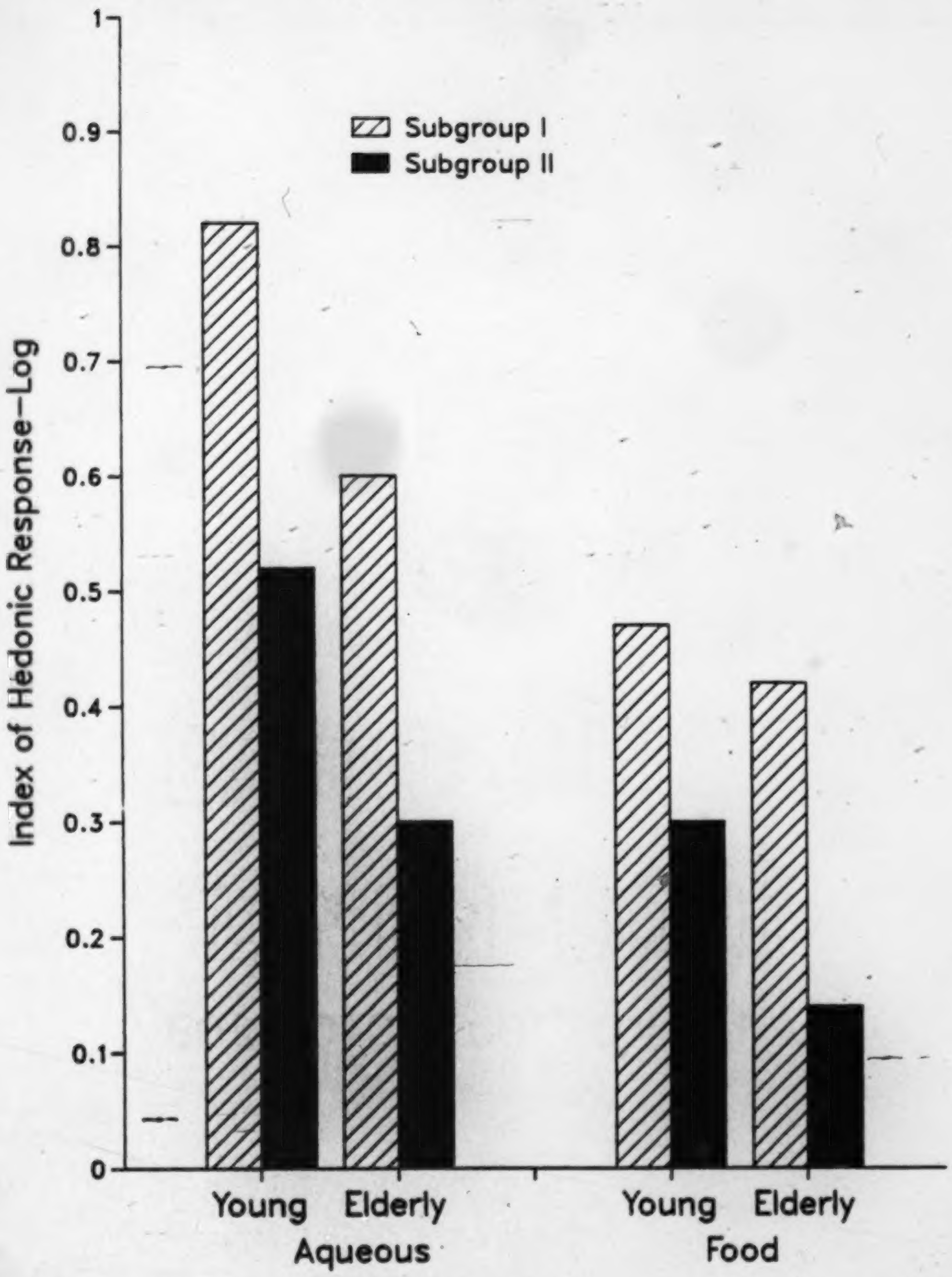
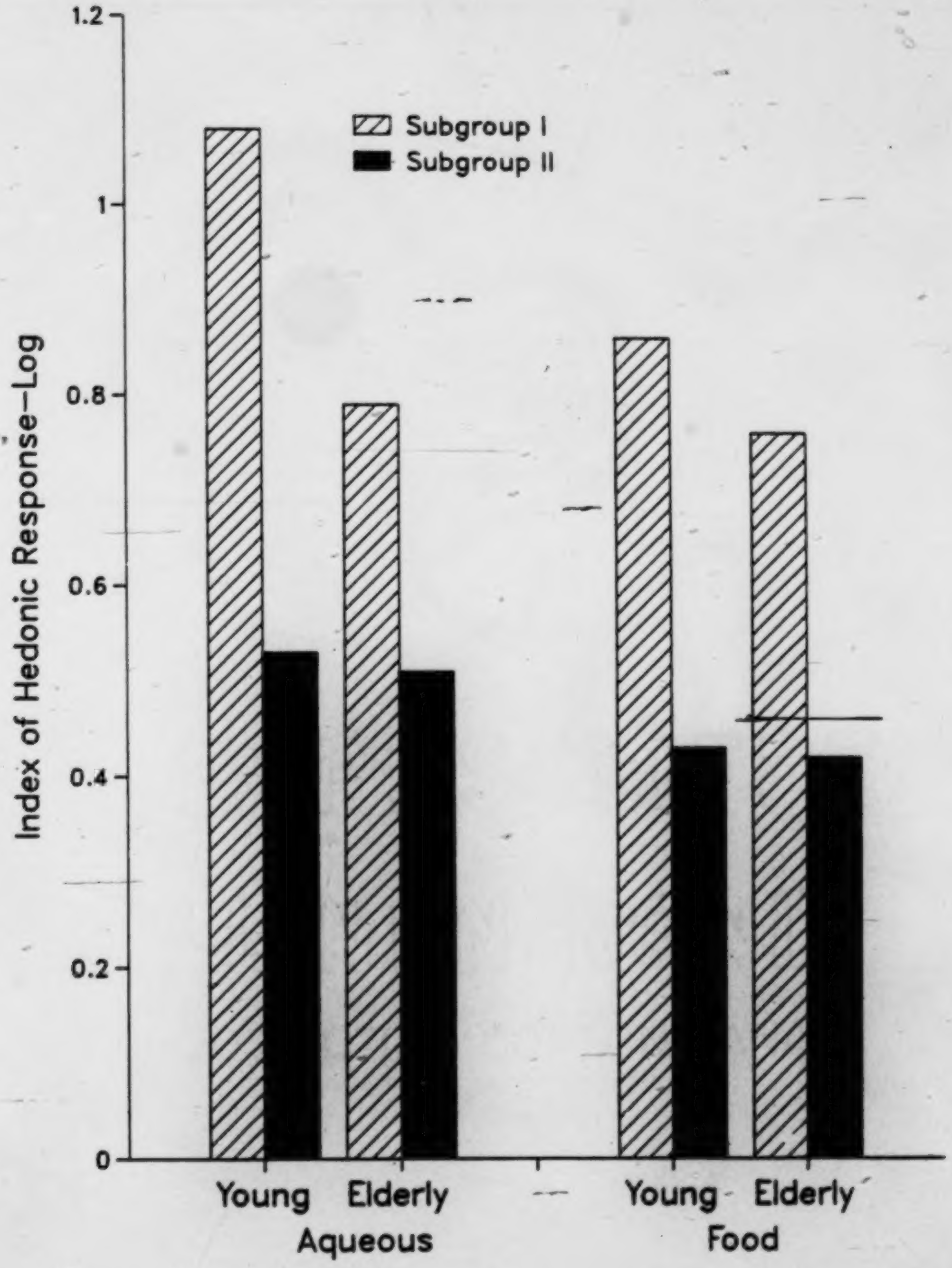


Figure 12: Overall index of hedonic response for the young and elderly subgroups: saltiness for aqueous and food systems



subgroup II in both aqueous ($p<0.01$) and food systems ($p<0.01$).

For both age groups, subgroup I had significantly higher indices of hedonic response than subgroup II (Table 35) indicating that the subgroup I exhibited strong likes and dislikes for both sourness and saltiness at suprathreshold concentrations.

Table 35: Overall indices of hedonic response for the young and elderly subgroups for two taste qualities and two systems

Taste Quality	System	Young		Elderly	
		Subgroup[1] I	Subgroup[1] II	Subgroup[1] I	Subgroup[1] II
Sourness	Aqueous	.82	.52**	.60	.30***,††
	Food	.47	.30*	.42	.14***,††
Saltiness	Aqueous	1.08	.53***	.79	.51*
	Food	.86	.43***	.76	.42*

[1] n=15

*,**,*** significant at $p < 0.05$, 0.01, 0.001, respectively, between subgroups within the same age group

†† significant at $p < 0.01$ between age groups within the same subgroup

DISCUSSION

1. Sampling of the Subjects

Obtaining a random sample of free-living elderly is difficult. In this study a random sample taken from the Alberta Health Care Insurance Plan files yielded 53% of the elderly group and 30% of the young group. Additional participants were obtained from volunteers, friends and seniors groups. Coleman and Krondl (1981) have previously reported difficulties in recruitment of free-living elderly. They obtained 48.5% of the original objective of 400.

2. Taste Perception

The present study used the method of magnitude estimation to assess taste perception at suprathreshold concentrations similar to those in foods normally encountered in the diet. Slopes of taste intensity over the suprathreshold range were flatter for the elderly than for the young. It is difficult to rule out the possibility that age differences observed could be attributable to differences in the use of magnitude estimation for scoring the samples. It is easier for the young to use a wide range of numbers (Stevens et al., 1984). The use of a restricted range of numbers by the elderly could result in flatter taste response slopes over the suprathreshold range. Initially a training session was held to introduce the subjects to the magnitude estimation methodology. In the training session subjects were encouraged to use a wide range of numbers including fractional numbers and to make ratio judgements. In addition, thirty subjects in each age group evaluated a hidden reference in each of the three replicates. Analysis of the data for replicates showed no significant differences. The results of the present study indicated that magnitude estimation was used effectively by the elderly for the rating of both intensity and pleasantness. We noted that the intensity data obtained from the elderly for sourness and saltiness in both systems were different. In addition, the intensity responses of the elderly and the young for saltiness in the the food system were not significantly different. These findings suggest that in this study specific sensory responses were measured and not merely age differences in ability to estimate magnitudes.

The slope of the taste function describes the relationship of perceived intensity and concentration. The slope values reported in the present study for sour and salt taste qualities are comparable to reported values (Cowart, 1983; Weiffenbach et al., 1986 and Weisfuse et al., 1986). Slight variations in slopes are inevitable as a result of differences in the concentrations of stimuli used in the studies. In addition ratings of intensity are influenced by the range of stimuli presented to each subject (McBride, 1982 and McBride, 1985). Although in the present study no significant differences were found in intensity responses for subjects with and without dentures, we cannot rule out an overall effect of the wearing of dentures by the elderly.

Several studies have investigated age-related changes in suprathreshold taste intensity perception. Many researchers have observed that the slopes of taste functions were flatter for the elderly than for the young (Cowart, 1983, Hyde and Feller, 1981 and Weiffenbach et al., 1986). In the present study the slopes of the taste functions for sourness and saltiness showed a decline with age for both aqueous solutions and simple food systems. The slopes of sour taste functions for the elderly and young groups were .47 and .77, respectively, for the aqueous system and .33 and .69, respectively, for the food system. The slopes for the elderly were significantly lower than those for the young at a level of $p<0.001$. The slopes of salt taste functions for the elderly and young groups were .50 and .71, respectively, for the aqueous system and .42 and .50, respectively, for the food system. In this case the slope for the elderly was significantly lower than that for the young for the aqueous system only ($p<0.001$). The ratios of the slopes generated by the young to those generated by the elderly were as follows: CA aqueous solution, 1.64; sour food system, 1.82; NaCl aqueous solution, 1.42 and salt food system, 1.19. The results showed that the effects of aging on suprathreshold taste sensation are less marked for saltiness than for sourness. Hyde and Feller (1981) also found that the age effect on salt taste was smaller than that on sourness.

The present study showed that results for aqueous solutions and simple food systems were dissimilar. For the elderly, the slope of the taste function (sourness) was significantly steeper ($p<0.05$) in the aqueous system than in the food system. However, for the elderly the slopes of the taste function (saltiness) did not significantly differ between the two systems. For the young, the slope of taste function was steeper in the aqueous system than in the food system for both sourness ($p<0.05$) and saltiness ($p<0.001$). In the present study the intensity ratings of the taste qualities were found to be significantly lower in the food system than in the aqueous system at the higher concentrations (above 12mM CA for sourness; above 160mM NaCl for saltiness for N=60). This difference in intensity estimates was less for the elderly than for the young. Hence, these results illustrate the importance of examining perceived taste intensity in food systems.

Pleasantness ratings in general were higher for the elderly than for the young for the two taste qualities and the two systems. The most preferred citric acid (CA) concentrations for the elderly and young were 6mM and 3mM, respectively, for the aqueous system and 12mM and 18mM, respectively, for the food system. The graph of pleasantness ratings for sourness in the aqueous system for the elderly group exhibited a pleateau at the low concentrations (3mM to 6mM) while the function for the young group is monotonic (decreases with increasing concentrations). Cowart (1983) and Murphy (1985) demonstrated that pleasantness ratings for sour aqueous solutions exhibit a decreasing monotonic trend for both elderly and young. In the present study for sourness in the food system, both age groups exhibited a parabolic relationship between pleasantness ratings and concentrations. The most preferred concentrations were in the mid range (12mM and 18mM). For elderly subjects, Murphy (1985) also reported a parabolic relationship between pleasantness ratings and concentrations for sourness in a food system. However, Murphy (1985) reported that the hedonic function for the young group was slightly U-shaped.

For saltiness in the aqueous system, the most preferred concentration was higher for the elderly (80mM) than for the young (20mM). Other researchers (Cowart, 1983 and Murphy, 1985) have reported that the most preferred NaCl concentration in aqueous system for elderly subjects was about 50mM NaCl. For saltiness in the food system both age groups rated the 80mM NaCl samples to be most pleasant. For the elderly group, the hedonic curves for saltiness in both systems are parabolic with a break point at 80mM NaCl. On the contrary, the young subjects generated a decreasing monotonic trend for the aqueous system but a parabolic curve for the food system with a break point at 80mM NaCl. In other studies (Cowart, 1983 and Murphy, 1985) a decreasing monotonic relationship between pleasantness ratings and salt concentration in aqueous system was observed in both the elderly and young subjects. However, Pangborn (1970) reported that for some people a parabolic hedonic curve was obtained. For these people the addition of NaCl to water improved the acceptability of water whereas for others it decreased the acceptability of the water (Pangborn, 1970).

In the present study, sourness hedonic responses for the aqueous system differed significantly from those for the food system. The pleasantness ratings for each of the six CA concentrations generated from the aqueous system were significantly different from those of the food system in both age groups. The subjects preferred a higher CA concentration (acidity level) in the food system than in aqueous system and preferred intermediate concentrations in the food system. For sourness, a significant medium effect on pleasantness ratings was found in both elderly ($p<0.05$) and young ($p<0.01$) groups. Similar results were also reported by Murphy (1985). In the present study for saltiness a significant ($p<0.05$) medium effect on hedonic function response was found in the young group only. Different hedonic responses were noted for the aqueous and food systems. Other researchers (Bertino et al., 1982; Moskowitz et al., 1974 and Murphy 1985) have also noted differences in hedonic response to aqueous and food systems. It is evident that taste preference for food systems should be evaluated.

3. Dietary Intake

The method used in this study to assess dietary intake was a combination of dietary recall (one day) and food records (three days). Kohrs et al. (1980) reported on the use of a combined recall and food record method and found that the food record overcame some of the problems encountered when one relies on the older individual to remember everything consumed. In this study, the researcher, a foods and nutrition specialist, collected all the dietary data herself and coded each item for computer analyses. Dietary intake was evaluated on three separate occasions (one from 24-hour recall and two from reviewing food records) so that important details regarding food products used, and methods of food preparation were collected. The use of food models (volumes prepared according to Nutrition Canada Specifications) and the use of a dietetic scale, when necessary, provided for more precision in assessment than would be possible for a single 24-hour recall. Young et al. (1952) indicated that the largest single error in dietary assessment is poor judgement of food portions. In the present study food records were reviewed with the subject each time to ensure that enough information was obtained about each item. The initial 24-hour recall provided information about each subject's food consumption pattern to enable probing for details that might have been forgotten in the subsequent food records. Campbell and Dodds (1967) noted that the ability of older people to recall accurately can be improved by skilled probing during the interview. By assessing dietary intake for more than one day and by using two different methods we were able to cross-check the information.

The need to assess a relatively large number of subjects placed a limitation on the number of days of food intake it was practically possible to assess. We used four days of food intake (three week days and one week-end day) to obtain a representative estimation of usual intake. Houser and Bebb (1981) recommended that a representative dietary intake must include weekend days and weekdays, probably in the true proportion of all days. Beaton et al. (1979) studied the dietary intakes of 30 females and illustrated a significant and consistent day of the week effect on absolute nutrient intakes among these females. Results of this study (Beaton et al., 1979) showed that working women consumed more calories on weekend days than on weekdays. Moreover, Richard and Roberge (1982) demonstrated that both women and men consumed significantly more calories and alcohol during weekend days than during weekdays, However, in women, a significant decrease in calcium intake was found during the weekend days. These authors (Richard and Roberge, 1982) concluded that the significant increase in calorie intake did not necessarily accompany a significant increase in other nutrients. For two of the young women in our study the food intake pattern fluctuated considerably so we assessed six and seven days of intake. Young et al., (1953) compared a seven-day intake to a 28-day food record and found the seven-day intake to be representative of intakes for the group. The authors (Young et al., 1953) noted that the pattern of daily means was so stable that less than a week's record would have provided an estimate of intake with little loss in precision. Some researchers (Hunt et al., 1983 and McGee et al., 1982) have found that estimates of usual dietary intake can be obtained from three days of food intake. Four-day records were advocated by Collier and Hankin (1963). Beaton et al. (1979) and Beaton et al. (1983) stated that, for many nutrients, intakes for three to seven days would provide a reasonable portrayal of the distribution of usual intakes. Balogh et al. (1971) used random repeat 24-hour recalls. They found that four recalls were necessary for a representative figure for some nutrients (e.g. calories) but that the representative number was higher for other nutrients. The evaluation of dietary vitamin A status poses more difficulties than the evaluation of many nutrients because vitamin A is found in relatively high concentrations in only a limited number of foods. Russell-Briefel et al. (1985) concluded that it is difficult to predict how many days of intake are needed to estimate the vitamin A intake of an individual because of large intra-individual variability. Hunt et al. (1983) evaluated the intra-individual variance in dietary intakes of a group of healthy free-living elderly men and women. These investigators (Hunt et al., 1983) found that the intakes of vitamin and mineral supplements, especially those nutrients taken in magadoses such as B-complex vitamins, ascorbic acid and zinc, could greatly increase the inter-individual variance. If dietary values are to be correlated with biological parameters, such as taste perception, a high degree of precision is required to avoid false negative correlations.

Dr Beaton, University of Toronto, recently developed a method for interpreting dietary data using a statistical approach. This is a probability judgement based on human population data. The lower the intake is in relation to the recommended intake (RNI), the greater is the likelihood that it is inadequate to meet the individual's actual requirement. The probability of nutrient deficiency at the level of RNI is only 0.025 (Anderson et al., 1982). Beaton's software package "Probability Assessment of Nutrient Intake" is designed to predict the risk of nutrient deficiency. Beaton has demonstrated a reasonable consistency between his estimate of inadequate intakes of iron and biochemical evidence of nutrient deficiency (Beaton, 1974).

The dietary data collected in this study indicate that in general, the elderly had poorer diets than the young. The energy intake of the young was significantly higher than that of the elderly. For the elderly the following nutrients were classified as at risk: folacin, 39%; calcium, 31%; zinc, 23%; vitamin A, 12%; and vitamin D, 11%. For the young the following nutrients were at risk: folacin, 16%; vitamin A, 11% and zinc, 11%. The protein intake of the elderly was significantly lower than that of the young ($p<0.005$). Protein intake varied among the subjects and seven percent of the elderly group were classified as being at risk for protein deficiency. Yearick et al. (1980) reported similar findings. Ten percent of the elderly were found to have an inadequate dietary intake of protein; nine percent of the group were found to have serum protein levels that were classified as below the deficiency level (Yearick et al., 1980). In the case of iron, the amount per 1000 kilocalories, was significantly higher for the elderly than for the young ($p<0.01$). In fact, for the young, the mean intake of iron was marginal; it was 13.2 mg as compared to the recommended level of 14 mg. Of course, the RNI for older women is lower. The quality of the diet for the young was influenced by the proportion of milk compared to meat products; the proportion of milk being greater for the young than for the elderly. The Nutrition Canada report stated that the elderly were at risk for deficiencies of vitamin A, folacin, thiamin, calcium and iron. Yearick et al. (1980) showed that about 40-50% of elderly women did not consume adequate vitamin A and Harrill and Cervone (1977) reported that some of their elderly women had suboptimal serum vitamin A levels. However, Baker et al. (1979) and Nutrition Canada (1973) found that serum vitamin A levels were adequate in this group of the population. These findings suggest that chronic inadequate intakes of vitamin A may lead to low serum levels (Barr et al., 1983). Rosenberg et al. (1982) suggest that a small portion of elderly are at risk for folacin deficiency. Inadequate intakes of falacin have been documented for 18 to 43 percent of the elderly (Elsborg et al., 1983; Garry et al., 1982 and Yearick et al., 1980). Webster and Leeming (1979) found that 24% of elderly subjects had low erythrcoyte folacin levels which were believed to be attributable to inadequate dietary intake. Garry et al. (1984) reported that 40% of the elderly subjects had folacin intake below 200 mcg, but only 8% exhibited low plasma folate levels. Wagner et al. (1981) found that the risk of folacin and zinc inadequacies was greater among elderly women of lower socioeconomic status.

Many factors can affect what foods are eaten. In this study significant effects of the following factors were found: annual income, educational attainment, and whether or not the subject ate alone. Davis et al. (1985) reported that income level influenced the quality of diet for the elderly. Some studies (Grotowski and Sims, 1978) have shown that elderly persons who eat alone tend to have lower nutrient intakes while other studies (Todhunter, 1979) show no effect suggesting differing individual reactions. Individual variation becomes more pronounced with aging. It is particularly difficult to find a group which represents the elderly in the population because many candidates are unwilling to cooperate in a study.

4. Relationships between Taste Perception and Dietary Intake

Significant correlations were noted between vitamin A intake and taste perception data. In view of the fact that vitamin A is known to be essential for the normal function of a variety of specialized epithelial tissue (Wolbach and Howe, 1925), this observation deserves careful consideration. Vitamin A deficiency has been shown to be related to abnormal taste sensation in humans (Hodges and Hodges, 1980 and Sauberlich et al., 1974) and in animals (Bernard et al., 1961). Mattes-Kulig and Henkin (1985) reported that in patients with dysgeusia (taste distortion) vitamin A intakes tended to be inadequate. For these patients taste abnormality was correlated with high nutritional risk and low energy intake.

For the young group significant negative correlations were noted between the zinc density of the diet and taste performance in terms of slope for sourness (food) and the slopes for saltiness (aqueous and food). No significant correlations were found between zinc in the diet and taste perception data for the elderly. However, several difficulties are encountered in trying to correlate zinc intake with biological parameters. Greger (1977) and Greger and Sciscoe (1977) attempted to correlate zinc intake and taste thresholds and did not find significant relationships between measurements of the taste parameters and diet. Even if zinc is present in the diet in recommended amounts, poor bioavailability may prevent zinc from exerting its essential function. Factors affecting the bioavailability of zinc have been extensively reviewed (Sandstead et al., 1982). Results in this study showed that the income level for the elderly was correlated with zinc intake. In addition,the educational level was related to iron intake for the elderly.

This study found distinct individual differences in taste intensity function. Subgroups of fifteen subjects with high and low values for slopes of taste function were examined. For the elderly in this study, a relationship between high values for slopes of taste function and greater overall percent risk of nutritional deficiency was found. In addition, an effect on preference response was documented: high values for slopes of taste function were associated with greater variability in preference response. There was a tendency to register greater dislike for the concentrations either higher or lower than the most preferred range.

One of the most important findings in this study was that the subgroup of the elderly with steeper slopes of taste function in food systems had a significantly higher overall index of nutritional risk (sourness, $p<0.05$ and saltiness, $p<0.05$). However, similar significant findings for index of nutritional risk were not observed either for the elderly in aqueous systems or in young groups. Mattes (1985) found that taste function was not related to dietary intake for young healthy adults. He postulated that there could be a relationship for some clinical conditions. The present study illustrated that for the young group there was no relationship between taste functions and overall nutritional risk, but for some elderly subjects a relationship between taste functions and overall nutritional risk was identified. Mattes (1985) also suggested that food systems may provide more powerful measures of taste function among groups of subjects than the aqueous tastants. Indeed, the results of this study demonstrated that for both sourness and saltiness the food systems were more useful in discriminating among groups of elderly subjects with different characteristics than were the aqueous systems.

Subgroup I of the elderly with steeper taste intensity slopes, showed the following characteristics: intensity and pleasantness responses with significantly greater variability, higher indices of nutritional risk, higher indices of hedonic response and lower pleasantness rating estimates at both limits of the suprathreshold range.

For both age group, subgroups with steeper taste intensity slopes exhibited stronger likes and dislikes in pleasantness ratings compared to the subgroups with flatter slopes. This may eventually influence their pattern of food intake. The observed differences in pleasantness ratings with steeper slopes of taste intensity, suggest a possible relationship between nutrient intake, taste perception and food intake for some elderly women.

CONCLUSIONS

Taste Perception

The measurement of suprathreshold taste perception by the method of magnitude estimation showed the following:

Taste intensity

Taste intensity measurements at the six concentrations chosen to represent the suprathreshold range were examined. For sourness, the samples evaluated contained citric acid in the following concentrations: 3, 6, 12, 18, 24 and 36mM in both aqueous solutions and apple drinks. For saltiness, the samples evaluated contained sodium chloride in the following concentrations: 20, 40, 80, 160, 320 and 640mM in both aqueous solutions and chicken soup.

1. The slopes of taste intensity functions for sourness and saltiness for the elderly females (70-79 years) were consistently flatter than those for the young females (20-29 years). The slopes for the elderly and young, respectively, were as follows: for sourness in the aqueous system, 0.47 and 0.77 ($p<0.001$) and in the food system, 0.33 and 0.60 ($p<0.001$); for saltiness in the aqueous system, 0.50 and 0.71 ($p<0.001$) and in the food system, 0.42 and 0.50 (non significant).
2. Taste intensity slopes for food systems were consistently flatter than those for aqueous systems. For sourness, the slopes for the food system were 0.33

for the elderly and 0.60 for the young; these values were significantly lower ($p<0.05$) than those for the aqueous system which were 0.47 and 0.77, for the elderly and young, respectively. For saltiness, the slope for the food system for the young was 0.50 which was significantly lower ($p<0.001$) than 0.71 for the aqueous system.

3. For each taste quality, intensity responses across the six concentrations were compared between the two age groups. For sourness in both aqueous and food systems, the age x concentration interaction in intensity response was significant ($p<0.001$). For saltiness in the aqueous system, the age x concentration interaction was significant ($p<0.001$).
4. For sourness in both aqueous and food systems and for saltiness in the aqueous solutions the elderly group perceived the two lowest concentrations to be significantly more intense than did the young group. At the two highest stimulus concentrations, the elderly group perceived the stimuli as significantly less intense than did the young.
5. Differences in taste intensity response across the six concentrations were found between the aqueous and food systems. For sourness, a significant ($p<0.01$) main effect for medium in intensity response was found in the young group. The medium x concentration interaction

for sourness was significant ($p<0.001$) for both the elderly and the young. For saltiness, the medium x concentration interaction in intensity response was significant ($p<0.001$) for the young group.

Taste Pleasantness:

Taste pleasantness response patterns were examined across the suprathreshold range.

6. For sourness and saltiness, differences were observed in the most preferred concentrations of the elderly and the young. For sourness, the most preferred concentrations were as follows: in the aqueous system, 6mM citric acid (CA) for the elderly and 3mM CA for the young; in the food system, 12mM CA for the elderly and 18mM CA for the young. For saltiness, the most preferred concentrations were as follows: in the aqueous system, 80mM NaCl for the elderly and 20mM NaCl for the young; in the food system, 80mM NaCl for both age groups.
7. Differences in pleasantness responses across the six concentrations were found between the elderly and the young. For aqueous systems, the age x concentration interaction in pleasantness responses was significant for both sourness ($p<0.001$) and saltiness ($p<0.01$).

8. Pleasantness responses were compared between the aqueous and food systems and significant differences were found. For sour pleasantness, a significant main effect for medium was found for both the elderly ($p<0.05$) and the young ($p<0.01$). The medium x concentration interaction for sourness was significant ($p<0.001$) for both age groups. For salt pleasantness, a significant main effect for medium ($p<0.05$) and a significant medium x concentration tion interaction ($p<0.001$) were found for the young group.

Dietary Intake

The quantitative assessment of dietary intakes for four days showed the following:

9. The mean energy intake of the elderly (1560 Kcal/day) was significantly less ($p<0.001$) than that of the young (1893 Kcal/day).
10. The low energy intake of the elderly was associated with poor intakes of several nutrients. The mean daily intakes of the elderly were significantly lower than those of the young for the following nutrients: protein ($p<0.01$), total carbohydrate ($p<0.001$), sugar ($p<0.01$), starch ($p<0.001$), riboflavin ($p<0.05$), calcium ($P<0.01$), phosphorus ($p<0.01$), sodium ($p<0.05$) and zinc ($p<0.05$).
11. The following mean daily nutrient intakes were less than the recommended nutrient intakes: for the

elderly: calcium (758mg), zinc (7.8mg) and folacin (178mcg) and for the young: iron (13.2mg).

12. The proportion of subjects consuming vitamin/mineral supplements was 47 percent of the elderly group and 43 percent of the young group. The use of vitamin/mineral supplements increased the mean daily intakes of calcium, zinc and folacin for the elderly and of iron for the young to levels above the recommended nutrient intakes. However, in many instances the total nutrient intakes from diet plus vitamin/mineral supplements reached high levels of over 500% of the recommended nutrient intakes.
13. Inadequate intakes were more frequent among the elderly than the young. For the elderly group, the nutrients with the greatest risk of inadequacy were as follows: folacin 39%, calcium 31%, zinc 23%, vitamin A 12% and vitamin D 11%. For the young group, the nutrients with greatest risk of inadequacy were as follows: folacin 16%, vitamin A 11%, zinc 11% and iron 9%.

Relationships between Taste Perception and Dietary Intake

Examination of the relationships between taste perception and dietary intake showed the following:

14. For the elderly, significant positive correlations were found between the percent risk of vitamin A deficiency and the slopes of all taste functions (i.e. for

sourness in the aqueous, ($p<0.05$) and food systems ($p<0.05$) and for saltiness in the aqueous ($p<0.05$) and food systems ($p<0.001$)).

15. For the elderly, significant positive correlations were also found between percent risk of calcium deficiency and slope for sourness in the food system ($p<0.05$), and slopes for saltiness in both the aqueous ($p<0.05$) and food ($p<0.01$) systems.
16. For the young, significant negative correlations were observed between nutrient density for zinc and the slope for sourness intensity in the food system ($p<0.01$), and slopes for saltiness intensity in the aqueous ($p<0.01$) and food ($p<0.01$) systems.
17. Within each age group the slopes of taste intensity functions were ranked and subgroups created. For both the elderly and young groups, subjects with steeper taste intensity slopes (subgroup I, $n=15$) exhibited larger variability in intensity and pleasantness ratings than subjects with flatter taste intensity slopes (subgroup II, $n=15$).
18. For subgroup I of the elderly (with steeper taste intensity slopes), there was a significant correlation between taste perception and nutrient intake expressed as an index of nutritional risk. An overall index of nutritional risk was computed for each subject as the average of the percent risk of nutrient deficiency values (protein, thiamin, riboflavin, folacin, vitamin

B_6, vitamin B_{12}, vitamin A, vitamin D, ascorbic acid, calcium and zinc). For the elderly, the mean index of nutritional risk for the subgroup I was significantly higher than that for subgroup II for the food systems for both taste qualities (sourness $p<0.05$, and saltiness, $p<0.01$).

19. For both age groups, subjects in subgroup I exhibited narrower ranges of preference and a greater dislike of stimulus concentrations at both limits of the suprathreshold range than did the subjects in subgroup II.
20. For both age groups, subgroup I had significantly higher indices of hedonic response (calculated as the absolute difference between the highest and the lowest log pleasantness ratings) for all tastants than subgroup II, indicating ~~that the~~ subgroup I exhibited strong likes and dislikes at suprathreshold stimulus concentrations.

One of the most important findings was that, for the elderly, the subgroup with steeper slopes of taste intensity was at greater nutritional risk than the subgroup with flatter slopes. The significant positive correlation between the risk of vitamin A deficiency and taste intensity responses suggests a possible relationship between vitamin A intake and taste perception.

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Appendix 1: The letter sent by Alberta Hospitals and Medical Care to request participation

Alberta Hospitals and Medical Care
Health Care Insurance Plan
118th Avenue and Groat Road,
Box 1360, Edmonton, Alberta,
Canada
T5J 2N3

March 15, 1985

Dear Sir/Madam:

The Department of Foods and Nutrition at the University of Alberta is studying the relationships between taste perception and the nutritional status of older men and women. They have approached the Department of Hospitals and Medical Care for assistance in recruiting people to participate in their study. The people selected include males and females in the 70-79 and 80+ age range plus control cases from the 20-29 age range.

The participant will be required to taste food samples and answer some questions about them. All samples will be foods consisting of commonly used ingredients. This information will be useful in developing, preparing and providing food of greater acceptability for elderly people.

Two researchers will make about five visits to collect the data. The participant will be asked to answer questions about food intake. Participants are free to refuse to answer any of the questions. All information given will be held in confidence and used only for research purposes. Any information on the outcome of the study will be provided to the participant as requested.

Your name has been included in a sample of the population taken from the Alberta Health Care Insurance Plan files. We chose people according to a pre-determined plan to include a broad range of people throughout the province.

If you are interested in participating in this study, which will begin soon and take an approximate period of one month, please complete the attached information sheet and return it in the enclosed postage-paid envelope. With your consent, a researcher will contact you at a later date to arrange for a personal interview.

... continued

Appendix 1: continued

Should you have any questions about this study, please contact one of the persons at the following numbers:

Dr. Jaya Chauhan - 432-5239 or 465-5887
Ms. Christina Ko - 439-4089
Ms. Susanna Ko - 439-5524

Thank you in advance for your participation.

Yours very truly,

A. V. Follett, M.D.
Senior Medical Consultant
Hospitals and Medical care

....

NAME: ______________________ TELEPHONE: HOME: ______________
ADDRESS: ___________________ BUSINESS: ______________
____
____

I, the undersigned, agree to participate in the Taste Perception and Nutritional Status study to be carried out by the University of Alberta, Department of Foods and Nutrition. The survey information will be provided to a researcher of the University of Alberta whom I understand, through a pre-arranged appointment, will visit me.

SIGNATURE: ______________________ DATE: ____________________

I do not wish to participate in the above study.

SIGNATURE: ______________________ DATE: ____________________

Appendix 2: Part I - Subject profile questionnaire

SUBJECT NO:________________ DATE:________________________
NAME:______________________ ADDRESS:_____________________
PHONE:_____________________ HRS. TO AVOID CONTACTING:_____
SEX: M____ F____ ETHNIC ORIGIN:________________

I. Health Status

1. Would you say that your health in general is
   Very Good___ Good(average)___ Poor___

2. Mobility of subject: Ambulatory___ Non-ambulatory__
   Limited (eg. with walker)___ Other___ (describe)____
   ____

3. Have you had any medical condition within the past 5 years which has caused changes in diet or changes in exercise and activity patterns?
   Yes___ No___
   (If 'yes' please specify)

   a) Medical condition: Note unusual appearance of
      skin ________________ eyes ________________
      teeth ________________ hair ________________
      gums ________________ nails ________________
      lips ________________ legs ________________
   b) Diet change (eg. low Cal, diabetic, Na restricted, modified fat, etc.)
   c) Activity change
   d) When did it occur?
      present___ within past year___ 1-5 years ago__

4. Have you had a medical checkup in the last year?
   Yes___ No___

5. Have you had any illnesses in the past year?
   Yes___ No___
   anemia ______________ kidney ______________
   diabetes ______________ infections ______________
   liver ______________ colds ______________
   heart ______________ psychological illness ____
   allergy ______________ G.I. ______________
   other ______________

6. Name of doctor: ________________ Phone:______________

... continued

Appendix 2: Part II - Subject profile questionnaire

7. During the past 6 months, have you regularly used any medication internally? (Drugs, pills, injections, hormones, tranquilizers, tonics, cough medicine, etc.)
   Yes___ No___
   (If yes, please specify)

   (If applicable) Does medication affect your appetite?
   Yes___ No___

8. Do you experience any problems with taste?
   Yes___ No___
   (If yes, please specify)

9. Do you experience any problems with smell?
   Yes___ No___
   (If yes, please specify)

10. Are you on a modified salt intake?
    Yes___ No___
    (If yes, please specify)

11. Do you add salt to your food at the table?
    Yes___ No___
    (If yes, please specify)

    Small amount___ Fair amount___ A lot___

12. Are you taking any vitamin/mineral supplements?
    Yes___ No___
    (If yes, please specify)
    a) What brand?
    b) How often do you take?
    c) How many do you take each day?
    d) How many do you take each week?
    e) Were they prescribed by a physician?
    Yes___ No___

13. Do you drink alcoholic beverages?
    Yes___ No___
    (If yes, please specify)
    a) Usual type of beverage ____________________
    b) No. of drinks per day ____________________
    c) No. of drinks per week ____________________

... continued

Appendix 2: Part II - continued

14. Do you smoke?
Yes___ No___
Usually smoke:
cigarettes___ pipe___ cigar___ other___
(If cigarettes, please specify)
Usual number of cigarettes smoked per day ____________

15. In the past year, has your weight varied by 5 lbs or more either up of down?
Yes___ No___
(If yes, please specify)
a) How much weight did you gain or lose?
b) Any significant reason known for the change?
(eg. illness, dieting)

16. Have you followed any type of a weight-reducing diet within the past year?
Yes___ No___
(If yes, please specify)
a) Name of diet
b) Duration

17. Do you wear dentures?
No___ Upper arch only___ Lower arch only___
Both arches___
(If applicable) How long have you been wearing dentures?
Do you wear dentures while eating?
Yes___ No___
(If no, please explain)

18. Do you have any difficulty in biting or chewing or swallowing severe enough to interfere with eating?
Yes___ No___
(If yes, please specify)
_____ missing teeth
_____ dentures do not fit
_____ other

19. How would you describe your appetite?
Very good___ Good (average)___ Poor___

20. With whom are meals usually eaten?
Alone___ Spouse___ Friend___ Family/Relative___

... continued

Appendix 2: Part II - continued

21. How many people share your living quarters with you?
0 1 2 3 4 5 6 or more
(If applicable) What is their relationship to you?
(Check all that apply.)
spouse___ son/daughter___ other relatives___
friend___ boarders___

22. Who usually prepares your food?
self___ spouse___ other household member___
meals on wheels___ other___

23. Do you regularly miss any meals?
Yes___ No___
(If yes, what is your usual menu pattern?)

24. Do you have any food dislikes or foods that disagree with you? (Foods that give you gas pains, heartburn, diarrhea, constipation, other discomforts.)
Yes___ No___
(If yes, please specify)

25. Do you have any food allergies?
Yes___ No___
(If yes, please specify)

26. Do you avoid eating any foods?
Yes___ No___
(If yes, please specify)

... continued

Appendix 2: Part II - continued

II. Demographic Information

Finally, we would like to ask you some questions about yourself.

1. Birthdate__________________ Age_________years.

2. What is the highest level of education you have completed? (Check all that apply.)
_____ elementary school
_____ high school graduate
_____ some high school
_____ career training (eg. trades, business school, armed forces)
_____ some university
_____ university degree
_____ no formal training

3. What is your marital status?
___single (never married)
___divorced/separated
___married
___widowed

4. Interviewer: indicate type of dwelling.
___single family house
___condominium
___rented room
___retirement community (eg. high-rise senior citizens apartments)
___institution
___other
___duplex
___apartment

5. What is your present yearly income? (self and spouse)
___less than $5,000
___$5,000 - $9,999
___$10,000 - $14,999
___$15,000 - $19,999
___$20,000 - $24,999
___$25,000 - $29,999
___$30,000 - $34,999
___$35,000 - $39,999
___$40,000 - $44,999
___$45,000 - $49,999
___$50,000 - $54,999
___$55,000+

6. Do you get any other form of nutritional support?

7. Contact: (one of the following)
Relative of another generation____________________
Previous employer__________ Pension Plan No._____
Driver's license________________

Appendix 3: Part I - The letter requesting elderly participants

University of Alberta
Edmonton

Department of Foods and Nutrition
Faculty of Home Economics

The Department of Foods and Nutrition at the University of Alberta is beginning a study to investigate taste perception and the nutritional status of older men and women. Participants in the age range of 70-79 and 80+ are required for the study.

You will be required to taste food samples and answer some questions about them. All samples will be foods consisting of commonly used ingredients. This information will be useful in developing, preparing and providing food of greater acceptability for elderly people.

A food quality researcher will make several visits to collect the data. You will also be asked to answer questions about food intake. Participants are free to refuse to answer any of the questions. All information given will be held in confidence and used only for research purposes.

Any information on the outcome of the study will be provided as requested. Those interested in participating in the study, which will begin mid-February and take an approximate period of one month, should contact us at the following numbers:

Dr. Jaya Chauhan - 432-3828
Ms. Christina Ko - 439-4089
Ms. Susanna Ko - 439-5524

Your help in this research project would be greatly appreciated. Thank You.

Appendix 3: Part II - The letter requesting young participants

University of Alberta
Edmonton

Department of Foods and Nutrition
Faculty of Home Economics

September 1985

Dear friends,

The Department of Foods and Nutrition at the University of Alberta is studying the relationships between taste perception and the nutritional status of older men and women. Participants in the age range of 20-29 are required for comparison.

In this study you will be asked to participate in five interviews. A Foods and Nutrition researcher will ask you about your food intake. You will be asked to keep a record of what you eat and drink for four days.

You will also be asked to taste food samples and to answer some questions about them. All samples are foods with commonly used ingredients. This information will be useful in developing, preparing and providing food of greater acceptability for the elderly people.

Participants are free to refuse to answer any of the questions. All information given will be kept confidential and used only for research purposes. Any information on the outcome of the study will be provided as requested. If you are interested in participating in this study, please contact me at the following numbers:

Ms. Susanna Ko - 432-5239 (B), 433-3683 (H)

Your help in this research project would be greatly appreciated. Thank You.

Yours truly,

Susanna Ko
Foods and Nutrition
Researcher

Appendix 4: Orientation to magnitude estimation

Name______________________________ Date__________________________

The following exercises acquaint you with Magnitude Estimation. In these exercises there are no limits to the positive numbers that you may choose.

1. Assuming the following lines each measure "100", put a cross on each line appropriate to the location of the corresponding number:

33 ____

25 ____

1 ____

91 ____

42 ____

5 ____

75.5 ____

66.6 ____

58 ____

82 ____

2. Give the first line a number to judge its length. Then assign the remaining lines numbers proportionate to the first line, eg. if a line is twice as long as the first line, give it a number twice as large; if a line is half as long, call it a number half as large. Don't hesitate to use decimals or fractions, and use numbers as large or small as you wish.

Actual Ratio:

______________________ 1.0

____ 2.4

_________________ 0.8

___________ 0.5

____ 1.8

__ 0.1

______________________ 1.0

... continued

Appendix 4: continued

3. In the accompanying booklet are contained 9 shapes:

a) assign a number to estimate the area of the first shape and without referring back to any shape, assign numbers to the area of each of the following shapes relative to the first. Numbers can be larger than, or fractions of, your first number, as you wish, and there is no "right" or "wrong" answer.

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________

b) give the first shape a number to estimate how much you like it. Without referring back to any shape, assign numbers to your degree of liking of each of the following shapes relative to the first. Again, use any numbers you like and, as it is your subjective judgements you are giving, there is no "right" or "wrong".

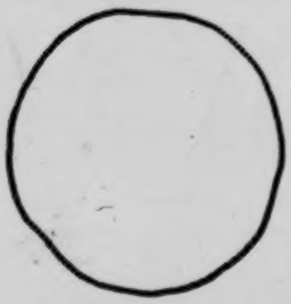
1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________

... continued

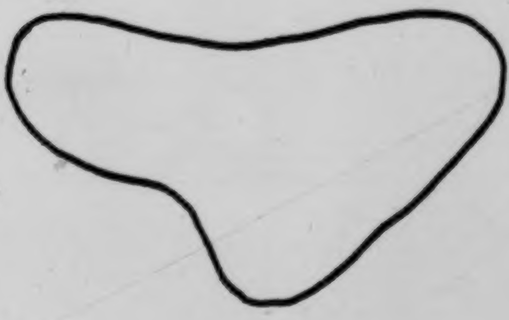
Appendix 4: continued

Shapes to be evalutated for orientation to
magnitude estimation exercise #3

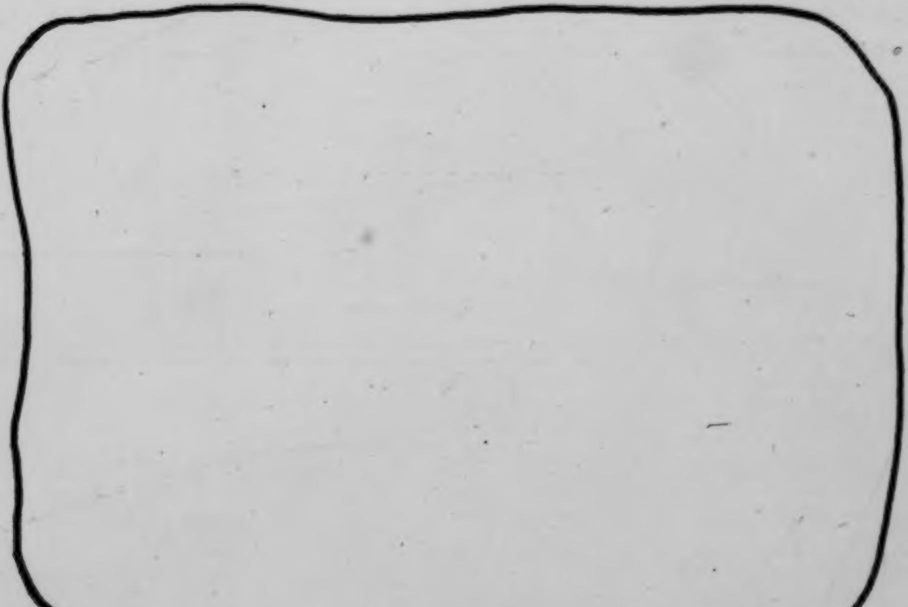
1.



2.



3.

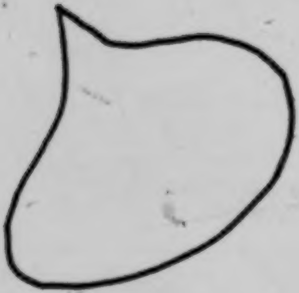


... continued

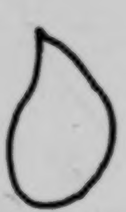
Appendix 4: continued

Shapes to be evalutated for orientation to magnitude estimation exercise #3

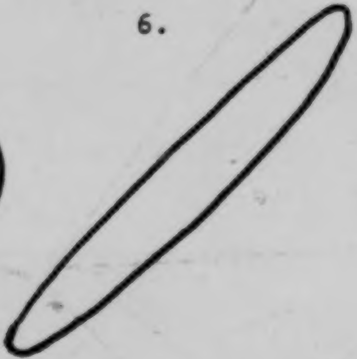
4.



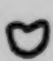
5.



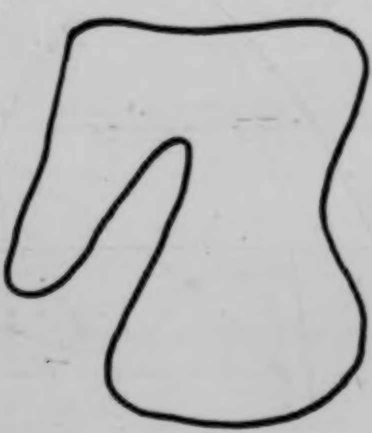
6.



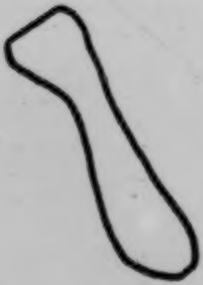
7.



8.



9.



Actual Ratio :
Shape no. 1. 1.0 6. 0.5
2. 1.5 7. 0.01
3. 9.4 8. 1.7
4. 0.8 9. 0.3
5. 0.2

Appendix 5: Analytical composition of the table salt

Chemical Analysis*		Typical	Limits
Calcium Sulphate	$CaSO_4$	0.16 %	0.4 % max
Calcium Chloride	$CaCl_2$	0.04 %	0.4 % max
Magnesium Chloride	$MgCl_2$	0.002%	0.4 % max
Filter Pad - APHA Test		0.10 mg	0.3 mg max
Iron	Fe	1.0 ppm	2.0 ppm max
Copper	Cu	0.5 ppm	1.0 ppm max
Moisture	H_2O	0.03 %	0.1 % max
Net Salt-Dry basis	NaCl	99.8 %	99.6 % min

Added:			
Yellow prussiate of soda- anti-caking agent		3.0 ppm	13.0 ppm max
Zeolex, free running agent		0.6 %	1.0 % max
Potassium iodide	KI	0.013 %	0.010 % min
Invert sugar, iodide stabilizer		0.02 %	

* data provided by The Canadian Salt Company Limited, Windsor®, August, 1985.

Appendix 6: Score card for taste assessment

NAME: DATE:

SUBJECT NO: SESSION:

SALIVARY pH:

Please taste each of the samples in the order indicated, rinsing with water to start and between samples. Do not swallow samples - just hold in mouth for 3 seconds. Taste the Reference (R) sample first. It has been assigned a score of 10. Assign the following samples numbers proportional to the Reference (R). If you think the samples numbers is twice as salty in intensity to R, assign the number 20; similarly, if you think it is only half as pleasant as R, assign 5. Retaste R after the third sample.

Sample Code.	R				R			
Saltiness Water	10				10			
Pleasantness	10				10			

Comments:

Sample Code.	R				R			
Saltiness Soup	10				10			
Pleasantness	10				10			

Comments:

Appendix 7: Instructions for tasting procedures

"In this session, you are required to judge the sourness (saltiness) and pleasantness of the series of samples displayed in front of you. The first sample of each row is your "reference". It has been assigned a number of 10 for its level of sourness (saltiness) and pleasantness. Try to remember the intensity and the pleasantness of this "reference" and compare this with the next three samples. If you think that the following sample is stronger in intensity, then assign a larger number proportional to the 10 of the "reference" e.g. if you think it is twice as strong as the "reference", then assign the number 20. Or, if you think the following sample is weaker than the "reference" by half much, then assign the number 5. Follow the same procedure to judge the pleasantness of the samples. You may use any whole numbers, fractions and decimals, but not negative numbers. Or, you may indicate the ratios of the intensity or the pleasantness of the test samples, as compared to the "reference". The test samples may be stronger, weaker or same as the "reference". The second "reference" is used to refresh your memory. The procedures of tasting are first to sip the entire content of the sample in the plastic cup, swoosh it around and hold it in your mouth for 3 seconds, taste it, then spit it out and give your judgements. You are required to rinse your mouth with water between every sample and to spit out the rinse water. If you wish, you may rinse your mouth twice to wash away the after-taste of the ~~previous~~ sample. If you have no questions, you may proceed.

Appendix 8: The order of sample presentation

Subject No.	Session 1	Session 2	Session 3
1	123456*	213456	654213
2	213546	564213	124356
3	312465	123564	654321
4	465312	564321	213546
5	564231	213465	465312
6	654321	564312	213465
7	132456	213546	564213
8	213564	654213	123456
9	312456	645312	312465
10	465321	123465	654231
11	564312	213564	123465
12	645321	213546	564321
13	123546	312456	654312
14	213456	123456	132465
15	564321	654321	312456
16	645312	654312	132456
17	123564	564231	645312
18	213465	645321	213456
19	564213	132465	123564
20	654231	312465	123546
21	123465	654231	465321
22	654312	465312	564312
23	124356	465321	564231
24	654213	123546	645321
25	132465	124356	213564
26	213456	465312	123546
27	213465	654312	132456
28	564213	123465	213546
29	124356	654213	564231
30	312456	123456	654231

	Citric Acid (mM)	NaCl (mM)
* 1 denoted solution at	3	20
2 denoted solution at	6	40
3 denoted solution at	12	80
4 denoted solution at	18	160
5 denoted solution at	24	320
6 denoted solution at	36	640

P.S.- Each subject received the same order of presentation for sour and salt qualities.

Appendix 9: Instructions for conducting the dietary interview

Conducting the dietary interview: General information

The techniques of dietary interview employed will determine greatly the accuracy of the results obtained. This is not to say that every interview should be exactly the same. Interviews may be modified according to the individual who is being interviewed. The interviewer should be able to judge the intelligence of the respondent and also how apprehensive she is about the interview itself.

The interview should be approached in a calm manner. Don't be in a hurry to pick up information because chances are some important food items will be missed.

1. Greet the respondent warmly at the door. Identify yourself.
2. Establish rapport with the respondent before beginning the interview. Explain why you are there, how long you will be there, and the type of information you are seeking. Don't give too much information about the exact nature of the study however.
3. Seat yourself beside the respondent and place the food model kit on the table beside you. It may be appropriate to have the suitcase on a small chair and food models can be extracted and placed on the table as required.
4. Be sincere and straightforward about the interview. Don't be machine-like. Ask questions as if you expect them to be answered.

... continued

Appendix 9: continued

5. Do not show surprise or disapproval of the respondent's replies, either by facial expression or tone of voice.
6. Listen carefully to the respondent's replies. You may get the answers to several questions at one time.
7. Repeat back what the respondent has told you to make sure you understand the information which has been reported.
8. Maintain a friendly manner but do not engage in small talk throughout the interview.
9. If an unexpected visitor interrupts your interview, come back another time. Don't try to finish the interview when you have lost the respondent's attention.
10. If the respondent appears to be ill - come back another time.

Specific Points on Conducting the Dietary Interview

1. When doing the two day recall of food intake, have the respondent recall the day he remembers the best.
2. Do not refer to any meals in the day - such as breakfast, lunch and supper. Some people do not follow such a pattern. Simply ask for an account of all the food items consumed throughout the day.

   e.g. Ask,"What was the first thing you did when you got up yesterday morning?" If the respondent says, "I had breakfast", then ask her what she had for breakfast.
3. Try having the respondent recall the activities of the previous days as these are often associated with food intakes.

... continued

Appendix 9: continued

4. Don't give negative or closed questions like: "Didn't you have anything else to eat last night?" Use open-ended questions such as "Can you think of anything else you had to eat last night?"
5. After you have acquired a list of foods in the order of consumption, go back and enquire about the amounts. Place all appropriate food models of the same type on the table equidistant from the respondent (eg. all the glass models).
6. Ask the respondent if any of the models resemble the amount she had to eat. eg. In the case of a beverage, ask:
   - i) from what type of container did you drink?
   - ii) If she says, "a glass", then display all the glasses and ask which glass resembles the one she drand from.
   - iii) Then ask how full that particular glass was.
   - iv) Did she drink its entire contents?
7. Always recheck a day's intake but do not suggest foods unless absolutely necessary as this will introduce a bias into the results.
8. If the respondent cannot remember her intake for a particular day, then have her look in the cupboards or the refrigerator. This may help to jar her memory.
9. Although the subject should be interviewed alone, where possible, a older respondent may require the help of another young family member, especially if she/he had prepared the meals for her.
10. Remember to ask the respondent if she ate everything on her plate. Also enquire about second helpings.

Appendix 10: Sample form for 24-hour dietary recall

DIETARY RECALL NAME:....................................

TIME OF DAY Enter Time from 00:01 to 24:00 in hours and minutes	FOOD CODE	FOOD OR DRINK	WORK AREA	AMOUNT CONSUMED		FOOD UNIT OR MODEL NO.
				Whole	Decimal	

Anthropometric Measurements

age: ____________

weight (kg): ____________

height (cm): ____________

ideal wt. for ht.: ____________

arm circum. (cm): ____________

triceps SF (mm): 1 ____________

2 ____________

3 ____________

av. ____________

elbow breadth (cm):

____

Appendix 11: Part I - Sample of a food record form

1-day record

INSTRUCTIONS

WHEN RECORDING FOOD INTAKE:

1. Please write down everything you eat or drink for the specified day on the following sheets.

2. In the first column, list the time of day the food or beverage was consumed.

3. In the second column, list the amount consumed as a volume, weight, number of pieces, etc. Whenever possible, copy the portion size or the appropriate portion eaten from cans, bottles and packages.

4. In the last column, please give us as many details as possible:
   - a) describe the kind of food eaten: for example, if you eat bread, write whether it is white, whole wheat, 60% whole wheat, etc.
   - b) describe the kind of food eaten: for example, raw, baked, boiled, pan-fried, deep-fried, etc.

5. When you are eating away from home, please continue to record what you eat.

6. Please remember to record all snacks, gum, candy, alcohol or other beverages, cough drops and especially vitamin or mineral supplements, and the amount you consume.

7. Please record the food actually eaten and not the amounts served.

An example of the correct method of filling out your food record is shown on the following page.

Should you have any difficulties or questions, please do not hesitate to contact one of us:

Christina Ko	432-5239
Susanna Ko	432-5239

Thank you for participating in this study.

... continued

Appendix 11: Part I - continued

24-HOUR FOOD RECORD

NAME______________

DATE______________

TIME OF DAY	AMOUNT	DESCRIPTION

Appendix 11: Part II - A Sample of Completed Food Record

CORRECT METHOD OF COMPLETING A 24-HOUR FOOD RECORD

TIME OF DAY	AMOUNT	DESCRIPTION
7:00 a.m.	2 slices	toasted white bread
	3 Tbs	Kraft strawberry jam
	6 oz	perked coffee
	1 tsp	sugar
	2 Tbs	homo milk
12:15 p.m.	1/2 10 oz can	Campbell's chicken noodle soup
	1 slice	rye bread
	3"x3"x1/4" slice	baked ham
	1 Tbs	mayonnaise
	3 - 2" diameter	Oreo cookies
6:30 p.m.	1	hamburger bun
	3"wide x 1" thick	broiled beef patty
	1 - 8 oz cup	frozen peas, boiled
	1 - 6"	banana
	4 oz	2% milk
10:30 p.m.	6 oz	tea
	2 - 3" square	unsalted soda crackers
	2"x1"x1/2" slice	cheddar cheese

Appendix 12: Consent form from the participants

Title of Research Project

A comparison of taste perception and dietary intake of elderly and young Albertans.

Explanation of Project

Elderly people often have nutritional problems. The purpose of this study is to find out what older Edmontonians eat and how will nourished they are. We are also trying to find out more about how the sense of taste changes with age.

You will be asked to participate in some interviews and tests which will be done in your home. A Foods and Nutrition researcher will visit you at home five times to ask you about your food intake. You will be asked to keep a record of what you eat and drink for 4 days.

You will be asked to taste some food samples and to answer some questions about how the samples taste. All samples are foods with commonly used ingredients. This information will be useful in developing, preparing and providing food for elderly people.

____________________________________(Name of Foods and Nutrition researcher) has explained to me that I will be interviewed at home. I will keep a dietary record for 4 days; I will undergo some body measurements. I will taste the food samples and answer questions about how the samples taste. I will be involved in the study for approximately one month.

I certify that the procedures have been described to me, and any questions that I have asked have been answered to my satisfaction. I understand that I have no obligation to consent to enter the study.

I understand that I am free to withdraw from the study should circumstances require me to do so. I have been assured that records relating to me will be kept confidential and that no information will be released or printed that would expose my personal identity without my permission.

I have read and understand the above information and hereby give consent to participate in the study.

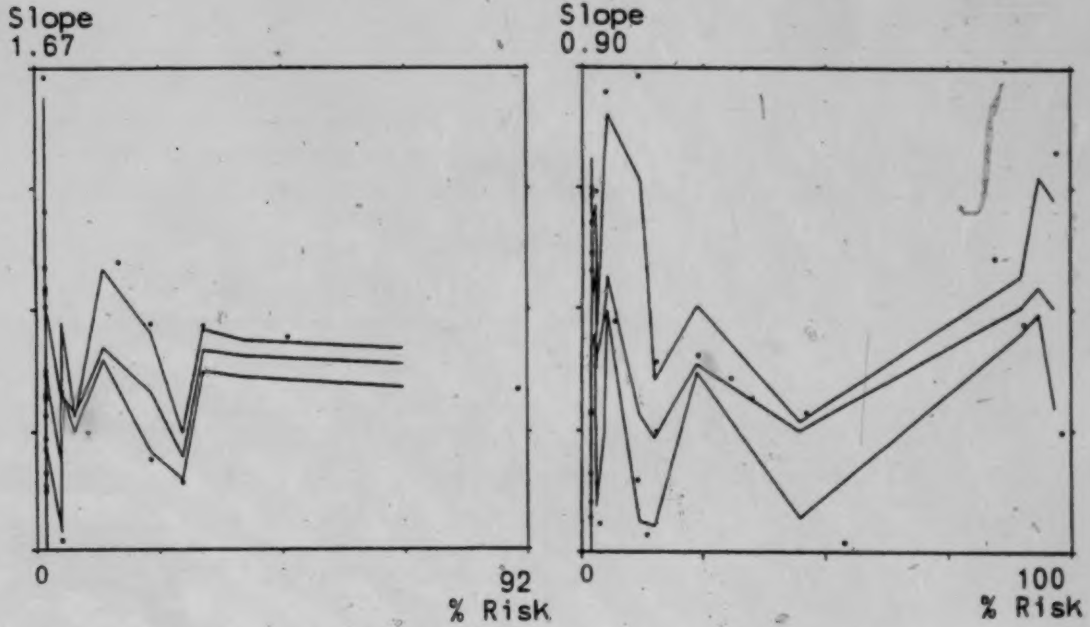
____________________________	____________________________
Participant's Signature	Signature of Researcher
____________________________	____________________________
Witness	Date

Appendix 13: Part I-Scatterplot of slope of taste intensity vs percent risk of zinc deficiency: Sourness

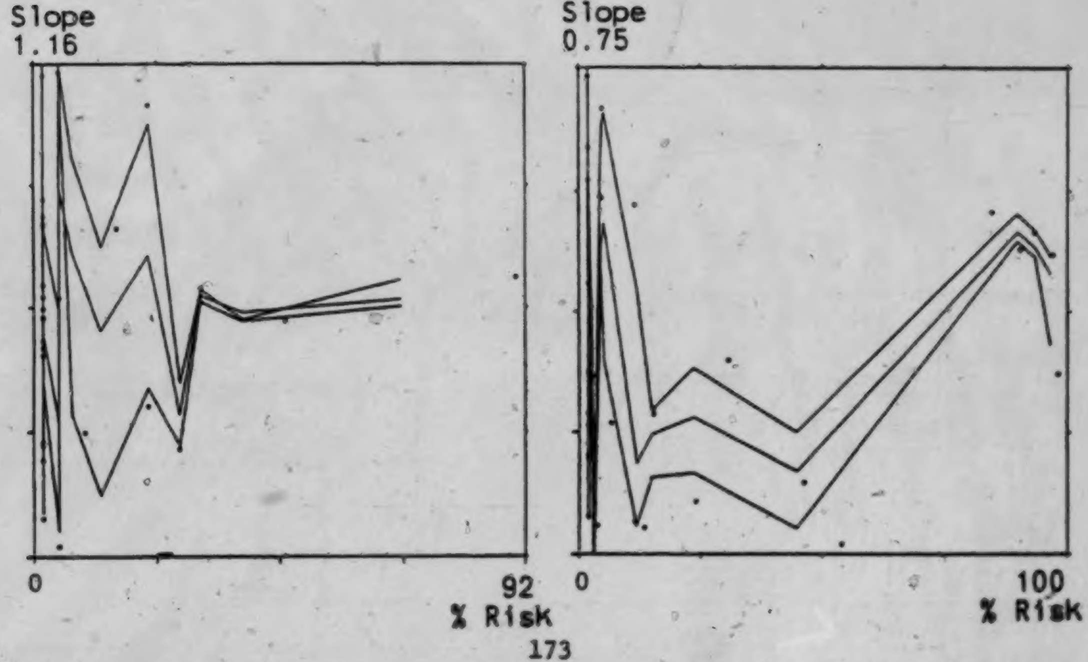
Young

Elderly

Aqueous



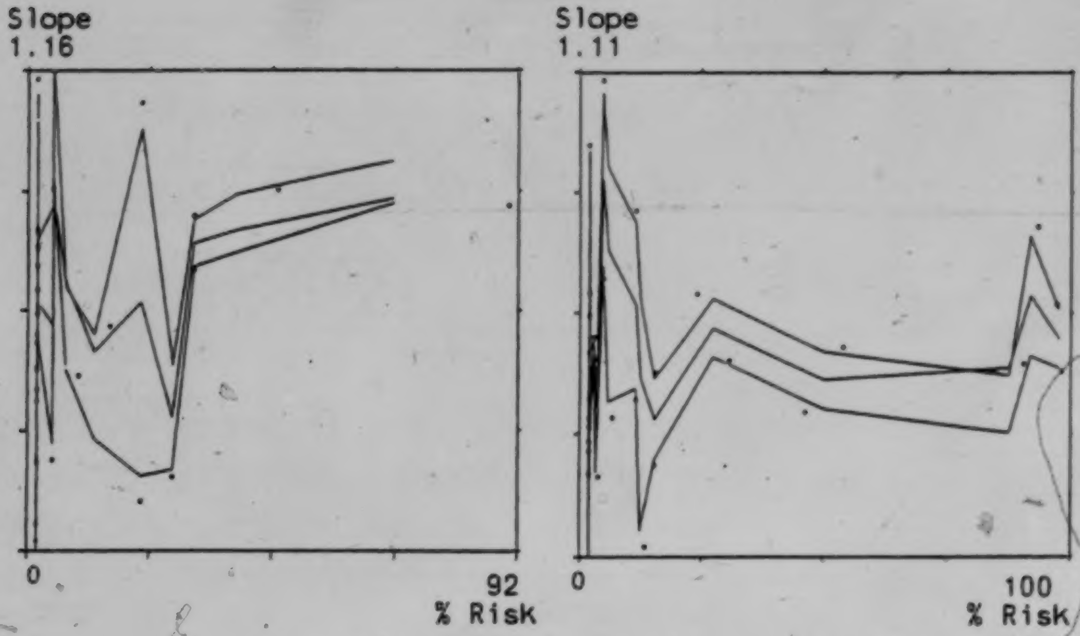
Food



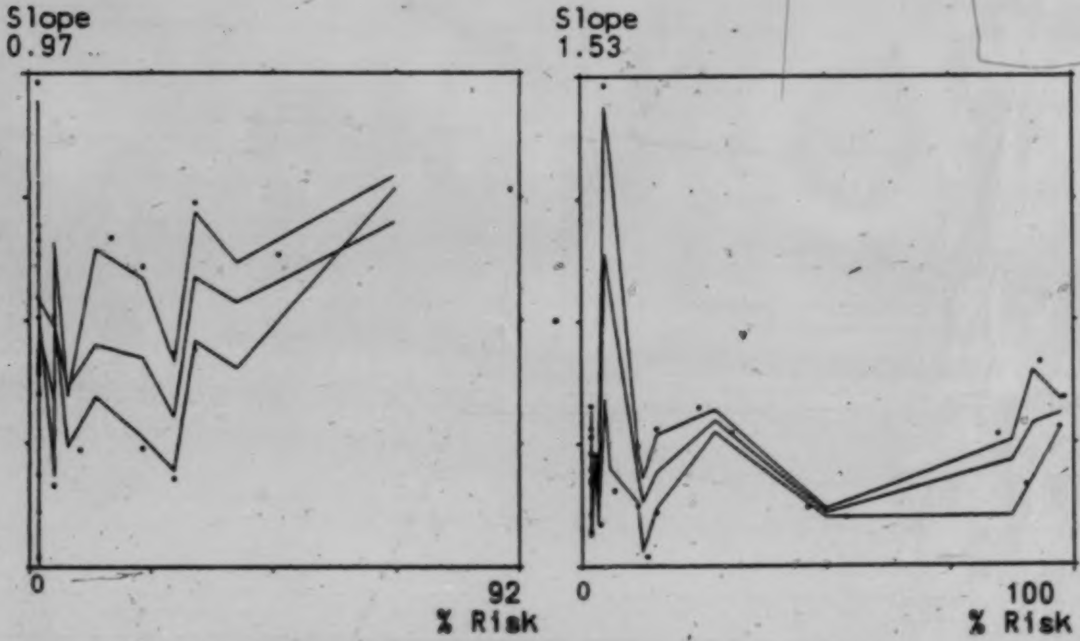
Appendix 13: Part II-Scatterplot of slope of taste intensity vs percent risk of zinc deficiency: Saltiness

Young Elderly

Aqueous



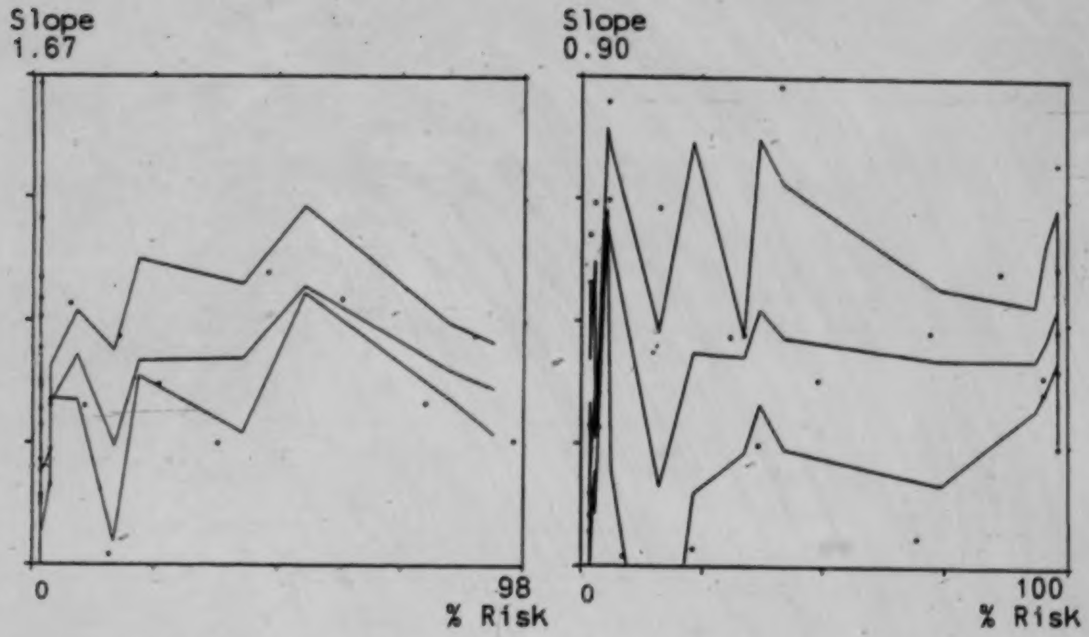
Food



Appendix 13: Part III-Scatterplot of slope of taste intensity vs percent risk of folacin deficiency: Sourness

Young Elderly

Aqueous



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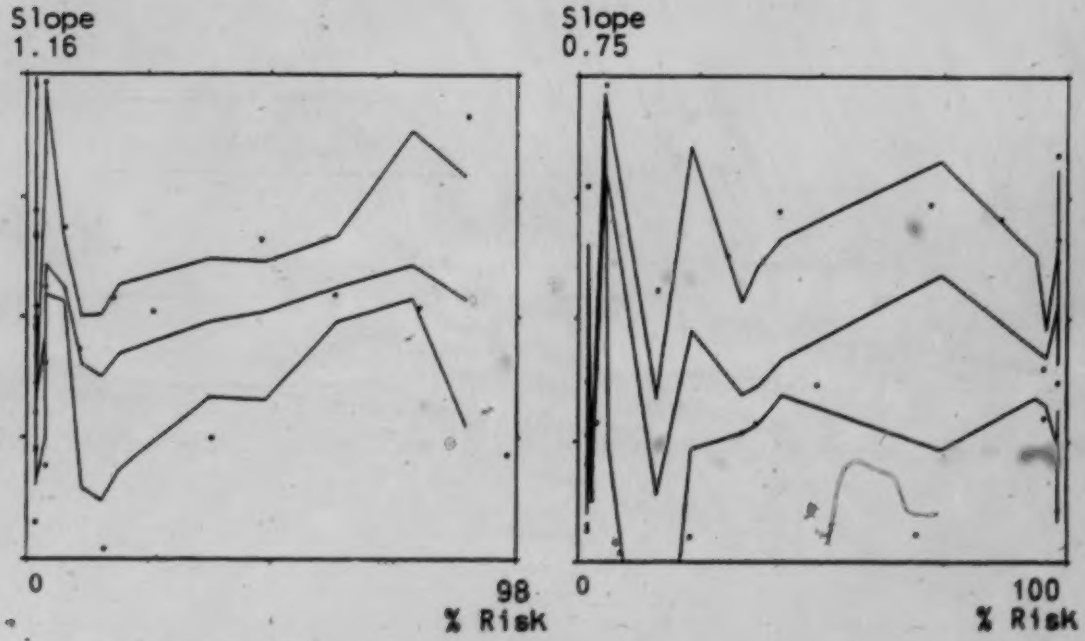
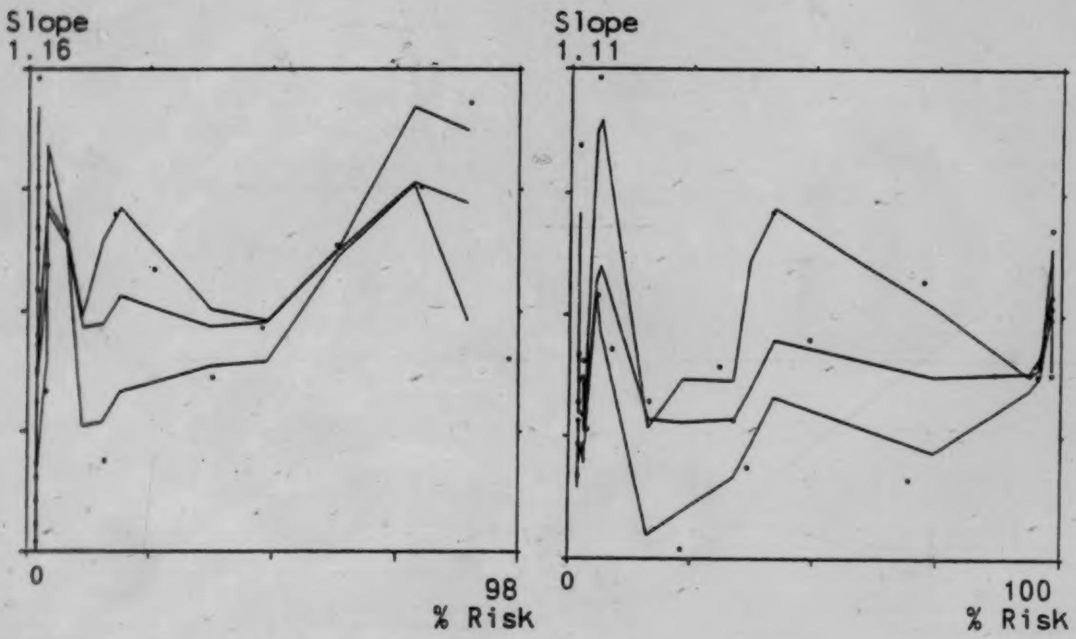


Appendix 13: Part IV-Scatterplot of slope of taste intensity vs percent risk of folacin deficiency: Saltiness

Young Elderly

Aqueous



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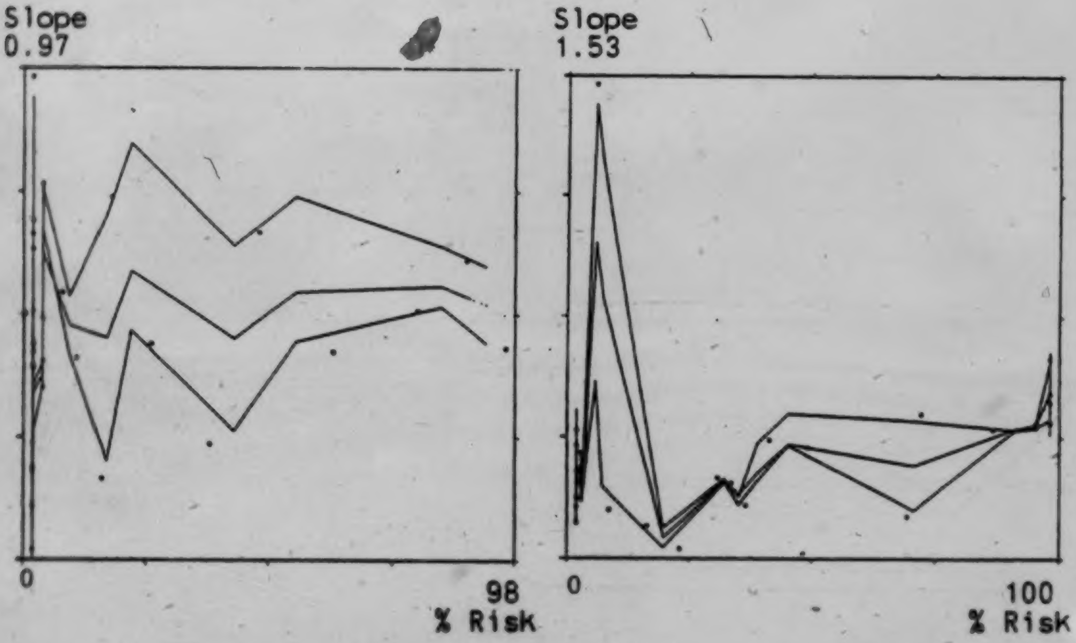
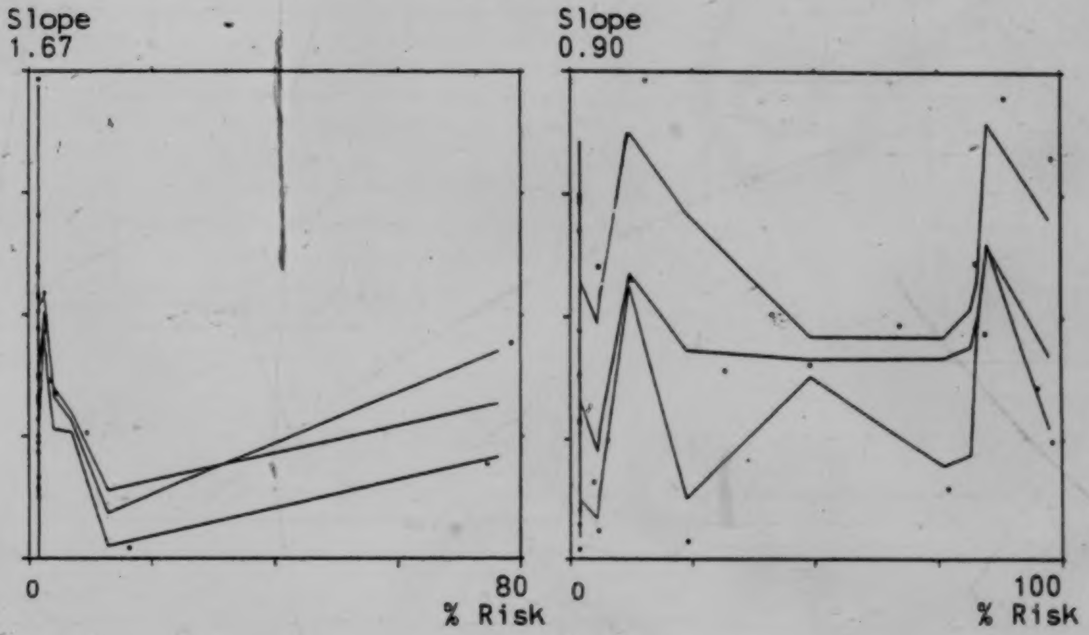


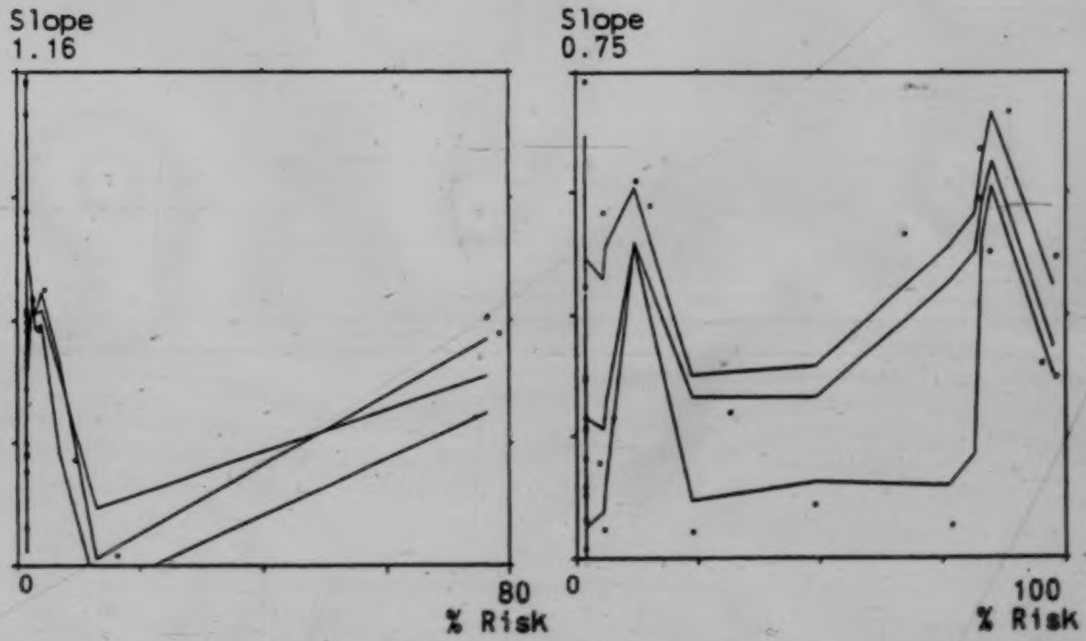
.Appendix 13: Part V-Scatterplot of slope of taste intensity vs percent risk of calcium deficiency: Sourness

Young Elderly

Aqueous



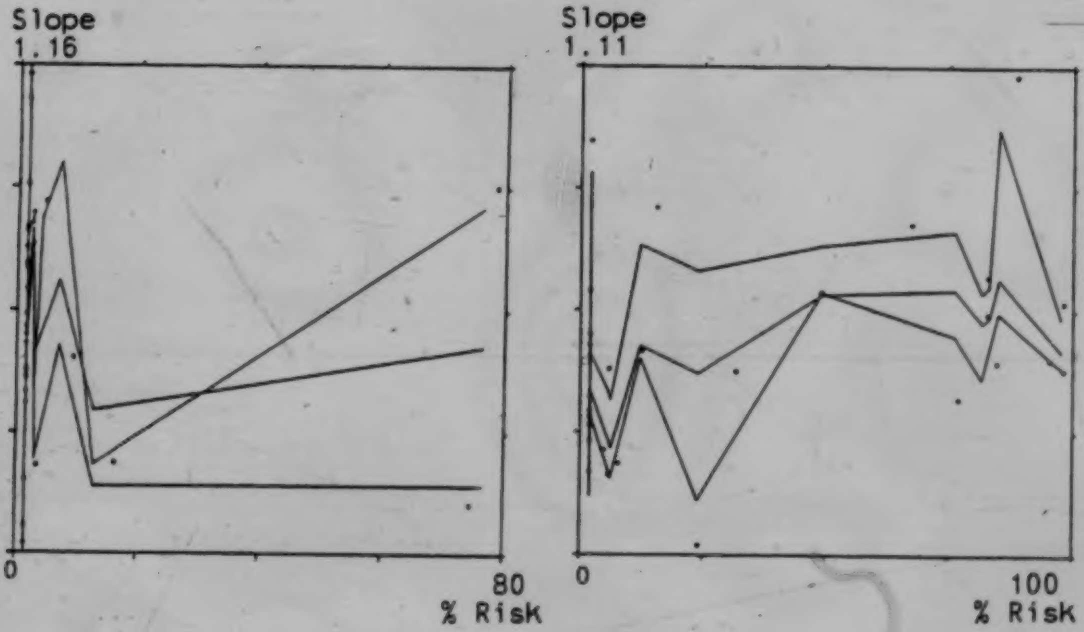
Food



Appendix 13: Part VI-Scatterplot of slope of taste intensity vs percent risk of calcium deficiency: Saltiness

Young Elderly

Aqueous



Food